

The Tree of Life Within Us

Origin and Evoltion of Life,
Philosophy of Nature,
and Mindfulness of the Human Body

Second Edition



Antón Bousquet

By meticulously observing the traces left by living things upon the earth, men have now uncovered enough clues to create a broad stroke painting of the story of life. From a single seed found in the sea, the watery blanket of the planet, when the earth was still young, life has grown into a broad, majestic tree, with innumerable branches covering the oceans and the continents, even reaching to the sky. Men represent one of these branches, which grew increasingly distant from other forms of life as one age succeeded to another, but the signs of the successive branching of the tree can still be discerned as we contemplate the bodies of our distant cousins. The apes of our time are living windows offering us a vision of our closest ancestors, and so do the small rodents running through our fields, or the fish that leisurely swim through our lakes. Beholding the tree of life, man may see in it his origin, his past, giving him the tools to think about his future.

The present book first represents an exploration of our bloodline, from the first seed of life until the emergence of our kind as a species, based on the knowledge offered to us by evolutionary biology, but disregarding the finest details and the technical language of the scientists to focus on the philosophical and spiritual implications of our evolution, its significance for our understanding of our own nature. The tree of life is here observed, from its roots to its trunk and the tip of its branches, but it also shows how large parts of the tree can be observed within our own bodies, as our flesh bears the traces left by numerous steps of our evolution. The tree of life is not only to be found around us but also within ourselves, and the reader will here be invited to reflect on the link between different milestones of our evolution and his experience of his own body, involving both his intellect and his senses, in the hope of leading him to a transformation of his perception of himself and to a mindfulness of the nature and story of the flesh supporting his being. Evolutionary biology may thus show us the way of a natural philosophy and broaden the horizon of our consciousness of what man is.

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2022-2023

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Contents

Table of Contents	
Abbreviations	
Introduction	1
I In The Water	13
1 The Cradle of Life: The Water and The Sea	15
2 Ingredients of Life: Organic Compounds	27
3 The Opening of Life: Self-replicating Molecules	45
3.1 The Key of Life	47
3.2 The Kindling of the Fire of Life: The Great Chain Reaction	55
3.3 Quenching of the Fire of Life: Natural Selection . .	59
4 Inside and Outside: the First Cells	69
5 The Old and the New: Senescence and Death	87
6 Building a Foundation for Life: Autotrophy	97
7 Life from Death: Heterotrophy	109
8 Life inside Life: Endosymbiosis	123
9 New Sky and New Life: Aerobic Cellular Respiration . .	133
10 Cores and Shell: Eukaryotic cells and Compartmental- ization	147

CONTENTS

11	Life in Motion: Flagellar Motility	161
12	Love and Division: Choanoflagellates and Sexual Reproduction	173
13	Strength in Numbers: Social cells	193
14	One with Many: Multi-cellularity and the birth of the Animal Kingdom	207
15	Swimming Vessels: Muscles and Complex Life Cycles . .	229
16	Sensing Body: Nerve Networks	243
17	Life with a Direction: Bilaterality, Polarity and Cephalization	257
18	From Many to One: Social Animals	271
19	Flowing Energy: Blood and Circulation	283
20	Discovering the Seas: Vision and Imaging	295
21	The Hard Life: Vertebrates and Mineralization	307
22	Between Sea and Land: From Fins to Limbs	317
II	Out Of The Water	329
1	New Realms for Vertebrate Life: The Land and the Air	331
1.1	The Land	332
1.2	The Air	339
2	Life on Land: The Four-legged Creatures	345
3	Born on the Dry Land: From Eggs to Live-birth	357
4	Hardened Creatures: Shields and Spikes	371
5	Fighting Ice and Fire: Warm Blood and Sweat	383
6	Coats of Life: Hair and Fur	395

CONTENTS

7	Drink of Life: Breasts and Milk	405
8	Life in the Trees: The Early Primates	419
9	Swinging, Striking, and Rising: Apes	433
10	Standing Up: From Ape to Early Man	447
11	Building with Hands and Words: Man	461
	Conclusion	475
	Timeline	489
	Bibliography	491

Abbreviations

Ch.	Chapter.
M.y.a.	Million years ago.
TBA.	Translation by the author.

Abbreviations

Introduction

What would the tree believe itself to be? It would consider itself to be roots, trunk, and leafage. It would think that it helps itself by taking root, but it is a mere pathway and passage. The earth, through the tree, allies itself with the honey of the sun, grows buds, opens up flowers, devises seeds, and the seed carries life, like a fire that has already been kindled but still remains invisible.

— Antoine de Saint-Exupéry, *Citadelle*¹

How arduous it is for us to fully appreciate the unique nature of our position, as men, the only living thing that can, for a passing moment, cease from devoting his strength and his intellect to the task of his own survival and the extension of his being through his fathering of children to contemplate the majesty of the tree of life, of which he is a mere branch among countless others. This tree bears a name that echoes through the depths of man's history, but the vision that we now have gained of it during the last centuries has profoundly transformed the way we see ourselves, our origin, and perhaps also our destiny. The tree of life represents the whole of this mysterious phenomenon bewitching parts of the earth, burning like a fire propagating itself throughout both seas and land, since the time the earth was still young, eons ago.

¹TBA. French original: “Que croirait l'arbre de soi-même ? Il se croirait racines, tronc et feuillages. Il croirait se servir en plantant ses racines, mais il n'est que voie et passage. La terre à travers lui se marie au miel du soleil, pousse des bourgeons, ouvre des fleurs, compose des graines, et la graine emporte la vie, comme un feu préparé mais invisible encore.” From: Antoine de Saint-Exupéry. *Oeuvres complètes II*. Gallimard, 1994. n.p.

The seed of life sprouted out of the watery earth, and its buds soon formed separate branches, which at a later point also cleaved themselves into branchlets, forming a tree-like structure growing to the pace set by the revolutions of the celestial wheels, the passing of time.

All the living creatures now present on earth are the leaves on the innumerable branches of the tree of life, whose shadow covers most of the land and the seas. Its seed has patiently grown into a force of nature, standing between earth and sky, sometimes also standing up to them both. As told by the French aviator and poet, life nonetheless also artfully allies the qualities and nature of the bright realm above with the ones of the dark one below, harmoniously weaving the fabric of both earth and sky, that is, water and soil on the one hand, and air and light on the other, to form something standing out of both realms, in a wondrous and perhaps unique display of the elegance of the creation.

For a long period, covering most of the history of mankind, man nonetheless failed to see the tree hidden below the emerald canopy, the branches and trunk uniting all living things and serving as an eternal testimony to their common parentage. He lived surrounded by myriads of creatures populating the forests and the plains, dwelling the abysses of the oceans or running through the flow of the rivers, and soaring through the clouds to bathe themselves in the brilliance of our gilded star, but he remained blind to the invisible and yet everlasting bond between all living things. Lacking curiosity, entrapped in the pursuits of his everyday life, or even constrained by his piety, his respect for the divine and the vision of his own origin handed to him through tradition, he remained like every other part of life unaware of his own belonging to the tree. As the French thinker reminds us:

How could the drops of water know themselves to be a river? Yet the river flows on. Or how could each cell of a tree know itself in terms of the tree? Yet the tree grows. ²

²From: ———. *The wisdom of the sands*. New York, Harcourt, Brace, 1950. Page 139. French original: “Comment la goutte d’eau se connaîtrait-elle comme fleuve ? Et cependant coule le fleuve. Comment chaque cellule de l’arbre se connaîtrait-elle en tant qu’arbre ? Et cependant grandit cet arbre.” From: Saint-Exupéry, *Oeuvres complètes II*, n.p.

Enshrouded in his ignorance, man still thrived and served the whole of life. He loved and battled to preserve the fire of life both supporting and consuming his flesh, and propagated it further over the earth and through time, work of the skies.

Man is inextricably part of the tree of life, but his unique ability to reason, to investigate, and to communicate his discoveries to his fellow men nonetheless allowed some of the drops of this living river running through time to see their own nature, and to begin to discern the whole of the flow in which they are caught. Diligent observers of nature, so-called “naturalists,” navigated through the most remote expanses of water and crossed the most inhospitable parts of the dry land to behold the astonishing variety of living creatures populating our planet, the incredible reach of the embrace of the branches of the tree of life, enfolding the arid deserts as well as the dank jungles, covering the watery abyss and the mountain peaks alike. They not only saw the differences between creatures but their similitude as well. Driven by their thirst for knowledge and understanding, they tore apart the flesh of animals, cut open living things to behold the intricacy of life, and they discovered that the skeleton of a swallow or a lizard is remarkably similar to our own, and that a continuity could be shown between what appears to be the most rudimentary members of the animal branch and the most complex ones. Creatures could be arrayed in a line to form a continuum, showing that there is no rigid barrier separating them objectively but rather only an almost continuous spectrum of life, from the humblest living thing unto the most exalted one. Through this patient work, involving a large number of men, we began to peer through the foliage of the tree of life, to see what united the living and what distinguished them from death, all that is not being consumed by the fire of life.

The work was strenuous, but the progress was extremely rapid, considering the scale of our history. One of the decisive elements that led man to finally see the vast web of intertwined branches forming the lower parts of the tree, and its trunk demonstrating the common origin of the whole, which sprouted out of a single seed, was the perception of the role played by the earth and the sky for the growth of the tree of life, not merely as providers of light and water, air and minerals to form the bulk of the body of living things but also as the hands shaping and guiding its growth. The most renowned of the diligent observers of nature, Charles Darwin,

first noticed how different species of finches living in distant lands appeared to share a common parentage, exhibiting a continuous gradation in the size of their beaks.³ It then appeared that such differences among related species were linked to the peculiarities of their surroundings: the patch of earth that they inhabited, the branches of the tree of life from which they drew their sustenance, and the nature of the sky in which they were plunged. Darwin's major achievement nonetheless was the discovery of the overarching principle driving the growth of the tree of life, *natural selection*, the fact that life is refined and evolves through minute steps, as the creatures that are unfit to their environment perish, while the fittest thrives and reproduce, passing on his remarkable traits to a new generation.

Following this major unveiling, man's look upon himself and upon life as a whole began to change. The simple and comforting vision offered to man by tradition suddenly turned blurry, depriving those who believed the theories of the observers of nature of the cloak of certainty that enfolded a large part of mankind. It is not only the origin and destiny of mankind that was left to be discovered, but also those of life as a whole. Man nonetheless enjoys the comfort of his chains and prison more than the unsettling freedom that comes with a life of vagrancy in the open country. Thinking of themselves as free from the yoke of tradition, many naturalists, the servants of an elusive "Science," focused their attention so intensively on the depiction of a new vision of the growth of the tree of life, as a history based on observation rather than a story handed over through tradition, that they overlooked, and many continue to do so, the philosophical and spiritual implications of this revolution. They search for new pieces to fill in the puzzle of life's evolution, in the wounds of the earth, the cliffs or the depths of the soil, but they seldom step back from their observations of the minute details of the creation to behold the whole, attempting to peer at the light beyond the horizon of their knowledge, their new certainties, and think about the source and destination of life, the meaning of the creation, a question that was at the very center of the tradition they discarded, and whose importance has not been diminished by the uncovering of the nature of life's evolution.

³See: Charles Darwin. *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*. John Murray, 1861. Page 397-398.

The work of the naturalists, of the scientists, is only a prelude to the true discovery of the nature of the tree of life. They lay the groundwork, uncover the details of the tree concealed by the work of the sky, hidden behind thick layers of dust. This foundation can then be used by those yearning to find their place in the whole of life, the whole of the creation, as they piece these countless discoveries together to produce a vivid and faithful picture, one that does not only include the majestic tree but also the earth in which it takes its roots and the skies towards which it extends its branches. As told by the French explorers of the heavens:

For, as with the tree, of man too you know nothing if you spread him out across his allotted span and disperse him in his differences. The tree is more than first a seed, then a stem, then a living trunk, and then dead timber. The tree is a slow, enduring force straining to win the sky.⁴

By beholding the trees covering the land, man may see a sign of the destiny of life, which began in water, the liquid body of the earth, and slowly conquered the oceans, crept onto the dry expanses above their surface, and then invaded the sky. The tree of life is like the oaks, the cedars, or the yews, the hairs of the earth, as they all begin their existence in the soil and slowly rise toward the heavens. Man himself has always dreamed of following the birds in their celestial explorations, and now that he has discovered the means of flying higher than them, he more than ever wishes to follow this upward trajectory, eager to see where it could lead him.

The key to our future, our destin-ation, may thus lie in our past, in our deepest nature, the veins, the bark, and the seed of the tree of life. To be prepared to embrace our future, we may first need to clearly see where we come from, and where we stand right now. Perhaps more importantly, we may also need to develop a talent for introspection, for looking at ourselves, according to

⁴From: Saint-Exupéry, *The wisdom of the sands*, Page 10. French original: “Car ainsi que de l’arbre, tu ne sais rien de l’homme si tu l’étales dans sa durée et le distribues dans ses différences. L’arbre n’est point semence, puis tige, puis tronc flexible, puis bois mort. Il ne faut point le diviser pour le connaître. L’arbre, c’est cette puissance qui lentement épouse le ciel.” From: Saint-Exupéry, *Oeuvres complètes II*, n.p.

our dual nature, firstly as creatures made of earth transformed by life into flesh, blood, and bones, a gigantic congregation of living cells consumed by the fire of life and working in unison from the day of our conception until the dusk of our existence, when we will be reclaimed by the soil under our feet, and secondly as spiritual beings, endowed with an ego capable of examining his own conscience. These two facets of man are nonetheless only the two sides of a same coin, inextricably joined to one another. An appropriation by man of his own nature will necessarily involve an appropriation of his own body, through a crystal-clear vision of what it is made of, how it functions, and what animates it. The light emitted by the fire of life must be welcomed in his eyes if he is to see the reflection of his own being, and this is why it is crucial for him to observe the flames of life, which enfold the tree without reducing it to ashes, like the burning bush of the immemorial tradition.

Fortunately, our nature is deeply intertwined with the one of the whole of the tree of life, and one consequence of this is the fact that the examination of the tree teaches us about ourselves, and conversely, the study of our own body shows us the nature of life as a whole. To see ourselves is to see the essence of life. As the aviator tells us:

. . . life is; as the tree is. And the stem is not a means that the seed has discovered for developing into a branch. Seed, stem and branch are the selfsame process of fulfillment.⁵

The secret of the nature of the tree, and the secret of life itself, is concealed within each young seed hung on its branches, and likewise, each one of us represents a seed of the tree of life, carrying the key of life within ourselves. Each one of our cells contains the information necessary to build our body, and in turn, this sum of information represents a heritage, a book that tells a large part of the story of life, containing the traces of the discoveries made by life through natural selection, from ourselves unto the very first

⁵From: Saint-Exupéry, *The wisdom of the sands*, Page 73. French original: “Mais la vie est. Comme est l’arbre. Et la tige n’est pas le moyen qu’a trouvé le germe pour devenir branche. Tige, germe et branche ne sont qu’un même épanouissement.” From: Saint-Exupéry, *Oeuvres complètes II*, n.p.

spark of life, of which we all descend. Our body represents an expression of this sum of information, a sculpture built from this blueprint, and each part of this body can tell us a part of the story of our ancestors, the tale of the growth of our branch of the tree of life, of its trunk, and ultimately also of its first seed.

The tree of life is thus not only to be seen in the innumerable living things covering the face of the earth, the depths of the seas, and the celestial heights, but also and perhaps foremost within us, in each part of our body: our skin, our bones, our flesh, our eyes, or our limbs. The book of life is inscribed in minuscule molecular letters deep inside the core of our cells, and its story is told as a series of enormous tapestries, named fingers, ears, legs, nerves, or hairs, with each one of them finding its source in a precise moment of the history of life, a precise ring in the trunk of the tree, and a precise subset of our ancestors.

The present book is meant to represent a journey of exploration of our own nature, through a depiction of the growth of the tree of life, focusing more specifically on our direct bloodline, the one that goes from the first seed of life unto mankind, excluding the branches of the tree parallel to our own, as a comprehensive description of the fullness of the tree of life would demand the redaction of numerous volumes. Following the first of the maxims of the temple of Apollo at Delphi, we will devote our strengths to “know ourselves” (γνῶθι σεαυτόν) rather than to vainly attempt to know the entirety of life. Each chapter will represent one step of our evolution, one season of growth of the tree of life, showing how a lone cell became an animal, how a marine creature crawled out of the waters to conquer the dry land, and how these creatures ultimately gave birth to our kind, following billions of years of struggle for survival and reproduction, in the hope of shedding light on the nature, the essence of life.

To explore of own nature is nonetheless only the first step of the journey. It may satisfy an intellectual curiosity and offer us a vision of our nature, but a vision is utterly useless if it is not interpreted by reason and does not become the source of a reaction, the trigger of an event coming as a response to this intrusion of light into man’s eyes, his world. The exploration of each one of the most crucial steps of our evolution indeed gives us an opportunity to better appropriate our own nature, and in particular our own body,

through which we experience the creation, touching the earth and living things as we are plunged in the air filling up the sky. This represents a true philosophy of nature, understood as a wisdom developed from a knowledge, which then becomes the source of a transformation of our self, of our behavior, and of the way we perceive the world around us. First knowing how the eyes came to be, we may better appreciate the wonder of sight, cherishing these parts of us, using the newfound consciousness of the role they play in our existence to view the world in a new light and more deeply interact with it. The intellectual foundation can become the source of a *re-flection*, us turning our attention back in time and toward ourselves through the combined use of our reason and our senses, allying thinking with experience, the mind and the body, ultimately paving the way for a projection of what our destination may be. Such a re-flection is therefore meant to be a practice rather than a mere aggregation of thoughts, something that is felt with the senses as much as it is understood with the mind, somewhat similar to what is now called “mindfulness” meditation. A problem with this term is nonetheless its focus on the “mind,” whereas such a practice involves as much the body and the senses as the mind and reason, which appear to be inextricably entangled. Our senses can also be filled with the experience of our own nature, as much as our intellect, and it is the marriage of both that may bear the most precious fruits.

At the end of each chapter, representing one step of our evolution, a short invitation to a re-flection practice, that is, a meditation involving both mind and body, the intellect and the senses, will be proposed to the reader, leaving him free to use it as a basis for the development of his own practice. One may then dedicate a small part of his day to a re-flection on a particular stage of the growth of the tree of life, directly linked with a specific part of our body, one that can be experienced with the senses. The father of the unveiling of the tree of life, Charles Darwin, himself said that “a man who dares to waste one hour of time has not discovered the value of life.”⁶ What task could be more valuable than the unveiling of our own nature, our origin and destination? Such a re-flection practice, ideally focusing on one step each day, may become the source of a greater appreciation of the miraculous

⁶From: Sarah Knowles Bolton. *Famous Men of Science*. T. Y. Crowell & Company, 1889. Page 363.

nature of the fire of life burning within us, and become the source of a fulfillment of our own nature, like a bud that is meant to open itself up and become a flower, turned toward the sky and the sun.

There is no need to reinvent the wheel concerning the practice of such re-flection. The methods developed for thousands of years by various spiritual movements may be used freely to achieve our goal. As this practice aims to ally a work of the mind with one of the senses, it may begin by finding an appropriate posture, a position of the body that would fit the requirement of the particular practice, not necessarily being the most comfortable, as tension on certain parts of the body may also bring our attention to certain aspects of its nature. A fitting location may also play a significant role, as the mind of the beginner will easily be distracted by the hustle and bustle of the world and may on the contrary be elevated by the contemplation of the quiet majesty of nature. Fortunately, the practice of a re-flection on our own nature should be self-reinforcing, as this journey will help us appropriate our body, and in turn this appropriation will develop our ability to walk further down the path. This therefore represents a journey of a lifetime, with our feet carving progressively deeper furrows on the way, trodden repeatedly year after year. The development of such a practice should be personal and in continuous evolution, and this is why the reader will only find invitations to a re-flection at the end of each step rather than fully guided meditations or precise instructions on how to link each stage of our evolution with an experience of one part of our body.

The spell cast upon many men, filling their lives with anguish and frustrations, may be effortlessly broken once one has appropriated his own nature, through the beholding of the magnificence of the tree of life and a sensory experience of how the tree can be seen within one's own flesh. Seeing their nature, the hand guiding the course of their existence, men may then finally gain control over their destiny, setting their own course within the range allowed to them by nature, ceasing to be mere leaves carried by the winds blowing over the tree of life.

Obstacles will nonetheless always stand in the way of the man making such a journey, and one of the most pervasive and insidious of these may be found in man's mind itself and, in particular, in the words he chooses to pave the way of his exploration and ap-

appropriation. Many of the naturalists who devoted their lives to the study of nature lost themselves in the profusion of technical terms devised by their peers and began to think of the categorization of the creation they created as an objective reality rather than a mere arbitrary division of the continuity of nature, rendered necessary by man's inability to grasp what is not beforehand cut into discrete pieces. Finding comfort in technical jargon, the worker of the mind, the scientist or the philosopher, begins to wrap himself up with a new coat of certainties, replacing the one of tradition that he previously discarded. Striving to not focus on the details of the tree of life but rather on the big picture that it represents, the present work therefore tries to minimize the use of scientific jargon, which may invite an overly intellectual reading rather than be the source of an experience, a vision, deliberately employing poetic language rather than scientific terms, something that may confuse the reader already familiar with the jargon of the discipline known as biology. For the same reasons, this book will also refrain from mentioning a precise timeline, the computations of the number of years separating us from each step of our evolution, firstly because such a timeline is continuously changing according to new discoveries and never the subject of a consensus, and secondly because it may distract us from the observation of the general movement of the growth of the tree. An attempt to count the rings of the tree of life will therefore only be shown at the very end of this book, as a piece of information not to be taken as either precise or certain.

The journey itself will be split into two parts, with the first taking place under water, in the liquid cradle in which life was born and took its first steps. It will offer a philosophically oriented vision of the way in which the first seed of life budded in the ocean and of the mechanism that drove the growth of this bud into the tree of life. It will show how the first sparks of life evolved into cells, and how life learned to overcome the threats to its existence posed by the rage of the earth and the sky. The transition from single-celled creatures to animals composed of innumerable cells will be depicted, as will the evolution of the first animals into several of our ancestors, such as marine worms or fishes.

Secondly, the journey will take us out of the sea and onto the dry land, as our distant forefathers developed limbs allowing them to extract themselves from their watery crib. The story of the transformation of the first four-legged land animals will progres-

sively be unfolded, showing how many of the features defining our body came to be, such as the emergence of warm-blood, hair, or breast-feeding. From lizard-like animals, our ancestors then began to look more like rodents, and then, as they took refuge in forests, they turned into the first primates. Climbing down from the trees, their descendants, the apes, were then driven to the plains and the grasslands, leading them to stand up and walk on two limbs, and to the emergence of our species, with our most unique feature appearing last in our evolution: our ability to reason using an articulated language.

Each one of the milestones of our evolution encountered during this journey will offer us an occasion to re-reflect on our nature, to ask ourselves questions and to develop our consciousness of the role played by the numerous parts of the machinery supporting our being. Feeling the fire of life burning within ourselves and delighting our mind with the awareness of the wonder it represents, we may then always keep in mind, and feel in our bones, the fact that our body contain the traces of the entire history of life, billions of years of relentless battle for survival, with our heritage being more ancient and enduring than the most imposing mountains towering over our cities or even the continents upon which these are built. Both humbled and made proud by this awareness of the antiquity of our nature, we should be joyful of living in a time when the opportunity to behold the magnificence of the tree of life is offered to us, as most of our forefathers did not have this chance. Filled with merriment should our hearts therefore be as we set ourselves on the path of such exploration.

Part I

In The Water

Chapter 1

The Cradle of Life: The Water and The Sea

The tree of life that we can contemplate around us is now as wide as it is strong. Its branches form a canopy covering most of the face of the earth, and each one of these branches is plunged in a unique environment, where they find sources of nourishment allowing them to perdure and grow, sources that are never exactly the same as the ones of their neighbors. Despite this diversity, all forms of life share a craving and a need for a certain substance, one that is to them more than a mere source of energy, a food, but rather represents the building block of their own being, the *medium* that shelters the myriad of cells forming their body. This substance is, of course, water.

The translucent liquid that we allow to pass through our body each day of our life tends to be taken for granted, and its everydayness has blinded many of us to its wondrous nature. Its abundance has led us to consider it what may be the least valuable of all liquids. It now comes in a virtually unlimited supply in our homes, and it is part of most of our daily rituals: washing, eating, cooking, or excretion. This everydayness of water must be broken in order for us to perceive and appreciate the role that it plays for life, as a whole, from the moment of its appearance on earth until the present instant. Such a work a rediscovery of water will here begin with an examination of its origin and its relationship with the earth.

The seas may have covered most of the surface of the earth for most of the history of our planet, but water nonetheless does not originate from it. It is familiar to us, but to the earth it is fundamentally *alien*. Indeed, as the planet was shaped into a sphere through the conjoint work of its spin and gravity, it remained too hot to allow any water present in the cloud of matter from which it was made to remain close to it, either on its surface or in its depths. Vaporized by mountains of molten iron; expelled from the body of the earth and sent up, high above the red skin of the young celestial body, and finally blown away by the solar winds, such water, if it even existed, disappeared forever in the cosmos, without leaving any trace of its passage. The ocean of magma, with its torrents of glowing, liquefied rock and its rivers of fiery iron, nonetheless slowly exhausted more and more of its strength as it revolved millions of times around its master, the greater force to which the earth is forced to submit itself and that always outshone it: the sun. The icy winds of the highest skies blew over the blazing sea, as its heat was radiated into the depths of space in the form of countless droplets of light fleeing the earth to embrace the cold, boundless darkness. Hiding its fiery nature in its depths, under a skin barely warm, the earth has been transformed. The sea of magma has been turned into a rocky desert. The scorching air of the surface has been replaced by a warm breeze.

At this point, the climate on the surface may have been hospitable to the presence of liquid water, but it was already too late: water was nowhere to be found. It had been scattered far away from the earth, out of the reach of the gravitational pull of its iron core. Fortunately, for us at least, a cosmic event nonetheless profoundly changed the nature of our planet. An encounter had already been planned long before any water would have been chased away from the sea of fire running upon the earth. Indeed, another celestial body, one of a more modest size compared to the earth, was already set upon a course that would lead it to collide with the planet whose surface had just turned into rock. Probably largely made of ice, but also perhaps with carbon and other substances that would become crucial prerequisites for the budding of the tree of life, this celestial body crashed onto the young planet, with such a force that it deeply pierced its crust, reviving for a moment the torrents of fire that once covered its entire surface. The two bodies were united, and from the violent penetration of

the icy bullet into the fiery body of the earth, a child was born into space, nonetheless remaining close to the body from which it was made: the moon.

As the earth and the visitor merged one into the other, like heavenly lovers passionately uniting their bodies, becoming one, ice and fire reached an equilibrium. The rivers of fire that briefly reemerged from the entrails of the earth were tamed by giant blocks of ice, producing a considerable amount of steam that soon enveloped the planet, but also producing something new: liquid water, which patiently ran and filled the deepest chasms, the fissures disfiguring the face of the earth, thereby smoothing it out and embellishing it. From a rocky wasteland, the planet was soon transformed into a vast ocean, from which parcels of land and mountain ranges stood out, offering a stark contrast between the softness of the waters and the roughness of the craggy peaks. As a woman delicately enfolding the flesh of her husband, the great sea becomes one with the earth, and yet remains distinct from it. Under the eyes of their offspring, the silvery globe that hovers above the planet, earth and sea form a new environment, one that is fragile but possesses an incredible potential.

The great sea indeed remains delicate. The balance between ice and fire that allowed it to take its liquid form and to form a thin coat covering the face of the earth is but a transient state, one that is bound to end someday. With each passing day, the fiery heart of the earth indeed grows colder and colder, whereas its master, the star that illuminates and pierces the sea continuously with its myriad of light rays, grows older. The fate of the sea is already set: it will one day be taken from the earth by the sun, unless another cataclysm occurs before that fatidic day. But before the sun kills the earth's bride, it will give birth to many creatures. It will be the womb of life, the soil out of which the tree of life will boldly rise toward the sky, filling up the great sea and covering the rocky wasteland.

The water forming the sea represents a link between the earth and sky, between the things that can be touched, the hard and stable matter upon which we can stand, and the great hollow, the unreachable depths that ineluctably remain out of the reach of our hands. Water is both earthly and heavenly. It possesses the hardness of granite when one tries to compress it, but it also

has the softness and fluidity of the air. It slips away instead of resisting. It lets light pass through rather than repel it. It is always in motion, stirred up by the winds blowing above it, and it permanently remains in a close relationship with its child: the moon, which gives rise to the tides continuously reshaping the coastline separating earth and sea, like an infant trying to attract the attention of his mother, and keeping her away from the arms of her husband. This nature of water is nonetheless linked with what surrounds it. Only when the balance between ice and fire is kept can it remain a link between earth and sky. Too cold and it becomes earth: an immobile block of ice as hard as a rock. Too hot and it is vaporized and becomes indistinguishable from the great void of space.

In order to better perceive the role played by water in the birth and growth of the tree of life, one must nonetheless also look at this substance more closely, and examine what it is itself made of and how it behaves. Most of us, during our youth spent on school benches, have learned the common scientific definition of water: it is a molecule composed of two atoms of hydrogen bonded to one atom of oxygen. The technical terms contained in this definition, once their meaning is learned, give us the impression that we are able to grasp what these elements are. The plastic models with balls and sticks that are used to teach chemistry lead us to falsely believe that we understand the nature of matter, and they also veil the limits of our knowledge. Even more accurate models, based on quantum physics, seeing the atoms in terms of diffuse clouds made of different force fields or even as probabilistic wave functions, only cast into deeper shadows what falls outside of the light of our knowledge. As said by the Greek philosopher, wisdom is to know that one does not know, something that applies also to the so-called “hard sciences.”

Our knowledge of nature is derived from direct observations. Men have built models from them, and have bestowed names to the “things” that they dis-covered. “Atoms” have received this name because they were thought to be unbreakable,¹ elementary building blocks of matter. This later was proven to be false, but it is of little importance. What matters is that atoms were identified as a kind of thing from which all the different substances observable on

¹From the Ancient Greek: *ἄτομος*, “indivisible.”

the earth or in the sky were made. These different kinds of atoms reacted with one another to form the world surrounding us. Man's understanding of these reactions began with the identification of the most central force governing them, which came from the observation of the three sub-atomic particles composing atoms: protons and neutrons forming their nucleus, and electrons surrounding it. A singular property of these particles would allow us to begin to explain how most substances of the earth reacted with each other: protons repulsed each other, but were attracted to electrons, while electrons also repulsed each other and were attracted to protons.

The play of attraction and repulsion between the elements composing atoms certainly is one of the most important foundations upon which our universe stands. Man may now be able to describe this play with extreme precision, but those pretending to understand its nature have only been blinded by the profusion of terms bestowed by scientists to describe their observations. The fundamental nature of the forces involved still escapes us, and we comfort ourselves by equating description, modeling, with the truth of nature. Therefore, in order to stay focused on the nature of the power play between the elements composing matter, technical terms will be avoided, as much as possible. We will take off the coat of certainty that has been laid over it by modern science, to concentrate our attention on the strife at work between particles sharing a same nature, and the affinity between differing ones, and this for a simple reason: it allows the perception of both a fundamental property of nature in general and of the nature of life in particular. Indeed, the balance between attraction and repulsion of particles of matter is not only at work inside atoms themselves: it is also the main force at work between atoms and groups of atoms, from the smallest speck of dust unto the largest star, and from the simplest molecule unto the most complex living structure in the known universe, that is, the human brain. The whole of nature can be depicted as a giant play between attraction and repulsion, affinity and strife, love and war, according to different levels of abstraction, one of the most fundamental of which being the aforementioned play between the parts forming atoms.²

²The play of attraction and repulsion between protons and electrons may nonetheless not be the most fundamental one. Protons are themselves formed of other particles, named quarks, and others forces are at play between these particles. For the purpose of the present book, the examination of more funda-

The primordial energy of the universe has been condensed into bits of matter as it was scattered across an increasingly larger area. Like miniature Russian dolls, nested into one another, these bits of matter swiftly formed secondary structures, determined by the very fabric of nature. Like a snowflake growing in freezing air, they took different shapes, according to a geometry based on the play of attraction between opposites and repulsion between those belonging to the same kind. Water offers us an example of such play, where an intricate combination of attraction and repulsion can be balanced to reach relative stability, thereby forming the substance that allows life to be. The participants in this play are two atoms of hydrogen and one of oxygen, but each one of them also represents the manifestation of a more minute play. A series of tensions, a battle is also waged within each atom, between the core and its outer part. More often than not, this conflict will naturally be resolved by the reaching of an equilibrium between the two opposing camps, inner and outer parts, through the departure or the incorporation of members of each side.

Another strife is nonetheless continuously waged at the same time, involving more complex mechanisms, a strife that leads to the formation of strong bonds between atoms themselves, and to the creation of somewhat stable assemblies of atoms, commonly as molecules. Water finds its origin in such an aggregation between two atoms of hydrogen and one atom of oxygen. The mechanism by which it is formed is somewhat more complex than a simple play of attraction and repulsion, as other factors are involved and the physical laws governing the microscopic world differ from the one we are used to experiencing with the material things around us, but such model can nonetheless help us to get a mental picture of the reaction process. The interplay of the so-called “electro-static” tensions between atoms can be represented as a colored surface enfolding a molecule, with different shades placed on different parts of it showing where the balance stands, whether attraction or repulsion is stronger at a particular location.³ The result of the

mental levels would nonetheless be superfluous, as these interactions, as much as they are known to us now, only play a secondary role in the origin and growth of life on earth.

³One should be reminded that the atom does not behave like a macroscopic object. Electrons and protons follow the disconcerting laws of quantum mechanics, which postulate a discontinuous nature of energy levels within atoms. Because of this, even though the nucleus and the electron cloud surrounding

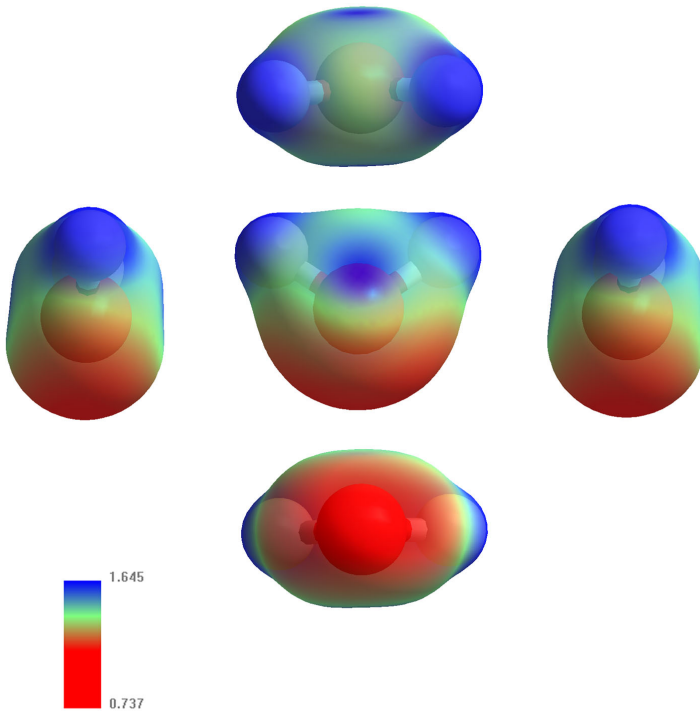


Figure 1.1: *The play of attraction and repulsion of a water molecule.*

interaction between the three atoms forming a water molecule can be seen in Fig. 1.1. What it shows is that even though the play between the atoms has reached a certain equilibrium, the resulting substance is far from homogeneous. Some of its parts do not exhibit the same properties as others. Water is what is called a “polar” substance, one that possesses an orientation. Like the atoms forming it, and like the particles composing them, it presents a contrast, an imbalance. The parts of it where the two hydrogen atoms are bound are clearly dominated by the cores (protons and neutrons), while the opposite side is ruled by the outer cloud (electrons). This imbalance gives to water its “polar” nature, and some of the properties allowing it to form the basis for life.

The unique shape and the great polarity of water, that is, the

it have opposite charges, they cannot collide one unto the other. A distance is maintained between the two.

great imbalance between one side that will attract some substances and the opposite side that will repel them, gives it a singular property that explains its central role in the birth and growth of the tree of life. Water is what is called a “universal solvent.” Each molecule of water not only possesses the ability to bind itself to other water molecules but also to an incredibly large range of other substances. By binding itself softly to others of its kind, it can form a harmonious assembly. A single droplet of water thereby forms a whole that tends to “stick together,” while its unique geometry and polarity favor a continuous movement within this whole. Each molecule can be seen as a minuscule soldier, part of a lilliputian army whose members tirelessly move to momentarily bind themselves to others, armed with the forces of attraction and repulsion that are carved in their own flesh. Their true power, both as individuals and as a community, is nonetheless only revealed when something foreign stumbles upon the border that they guard. When the water drop enters into contact with another kind of substance, each one of the water molecules touching it tries to bind itself to it, and they are more skilled at this than any other. When the bond between them is sufficiently strong, the miniature soldier can carry its cargo deeper inside its camp, driven by the continuous motion of the whole of the army. In other words, water is able to “dissolve” aggregates of foreign substances and carry their components in its midst, following the apparently random movements of the molecules. This property of water, whose origin and inner workings are invisible to the naked eye and until modern times remained a mystery, is what makes it a pillar of life.

Water is inextricably tied to all forms of life known to us because it is more than something that life feeds on, something that we drink to provide nourishment to our bodies. Water, first of all, opens up a **space**, in which other substances can dwell and that facilitates the emergence of reactions and interactions between them. Water is sky brought down to earth, something that shares both an earthly and heavenly nature, and yet also incarnates something that transcends both. The great mass of the waters that is assembled together and covers most of the face of the earth is the great sea, the ocean. It represents a third realm, caught between earth and sky, tearing them both apart to open up an enclave inside of which something new may emerge.

The sea is nonetheless more than a mere expanse of water.

Water represents the medium in which a myriad of substances are dissolved, carried, and brought into contact. The giant orb of fire around which the earth revolves is closely involved in the composition of the sea. Its envoys, the sunrays, indeed strike the surface of the sea and their heat carries minute droplets of water up in the sky. These are then hoisted by the winds and shaped into clouds that pour down their precious liquid when they encounter a colder gust. Flowing down from the peaks standing out of the sea, this water, purified by the sun itself, runs back toward its lowly home, but not without carrying out a peculiar mission: it collects samples of the minerals out of which the continents are made, to bring them back to the sea, thereby enriching it.

Water is thus not only a space: it is also a **vehicle**. It not only takes away bits of earth by eroding its lithic crust, but also draws other substances from the air directly found above the sea. Some of the most fundamental building blocks of life are thus brought inside the body of the sea, such as carbon. At the time immediately preceding the emergence of life in the sea, the sky and the air found above earth and sea were nonetheless very different than those that we can experience now. The air contained virtually no oxygen, but rather plenty of methane, which may have given to the sky an orange tint, even though the shades of blue that we know may also have been present, while the dry land would have been painted with red hues because of the presence of iron-rich basalt, or gentler gray tones where granite could be found.

Adorned with the fruit of the unceasing work of its minuscule army, the innumerable substances brought inside of its body, the sea represents the **cradle of life**. It is a medium ideally suited for the emergence of a complex chain of reactions between molecules, bits of matter extracted from the earth and the sky, and brought together through the agency and work of water. The sea is like a giant egg, a medium and a space in which something can develop itself and grow, until it can break out of it, once it is sufficiently mature. In the case of life, it can therefore be said that the egg came before the chicken. The cradle was patiently woven throughout the ages by nature itself, long before the infant that it would bear was conceived. This nonetheless only represents the setting up of the stage of the great spectacle of life on earth. This stage has yet to be prepared before the actors can arrive. The second step of this preparation comes with the fabrication of the precursors,

the building blocks of life.

Re-flection: The Water Within Us

The sound of the waves crashing onto the craggy shore fills our ears, while the droplets scattered by the rocks soon rejoin the whole of the sea. As the ocean recedes, retreating briefly, it rejoices our ears with a soothing song, the whispers of the countless soldiers of this host, laughing at our insignificance.

Our eyes are closed and the bustle of our world fades into silence. The tunes of the earth and the whistling of the sky fall into oblivion, while our skin is awakened, and our fingers catch our attention. As the king of the senses is made blind, the others seize their chance to shine.

Skin against skin, the softness of the flesh is once again revealed, together with its earthly nature, contrasting with the immateriality of the air. As our palms pass on our forehead and soon embrace our cheeks, the rigidity of our bones gives place to the fluidity of the blood-soaked flesh, and as our fingertips press on the vessel to feel what it contains, we are reminded that we are skin, we are bones, but most of all, we are water.

Extensions of the waves carving the shorelines, tide after tide, eon after eon, the living conceal in their midst the same relentless commotion. If the fire of life can burn within our chest, and if our blood flows within our veins, it is because the body is water, and the diligent and selfless soldiers of the sea unceasingly carry what is to be burned by this furnace we call a living being.

By their size, they appear powerless, but because of their minute nature, they slip into places where others would be stuck, fluidly escaping anything grasping them. Taking a sip of the liquid of life into our mouth, it slowly covers our tongue, touching our palate and mingling with our saliva, while its sober savor is scrutinized.

Once the taste of the liquid has been recognized, the doorway to the entrails opens. The fluid runs down the throat, leaving the reach of the senses, entering the flesh. Absorbed into the body, this sip of water becomes part of ourselves.

More numerous than the drops of water contained in a vast lake are the bits of water, the aquatic soldiers, forming this mouthful, and these are now part of ourselves, servants of our being.

Carried up to the sky by the envoys of the sun and the winds sweeping the seas, this water has been purified by the heavenly fire before entering the celestial vaults. Rained down over the dry land as these vaults were opened, it formed the rivers from which we draw the liquid quenching our thirst. These bits of the sea forming the bulk of our flesh, having soared through the sky, are now indiscernible from the rest of the body, from what makes us what we are.

Passing our hands over our thighs, these bits of water are both sensors and sensed. They are what is touched and felt by our fingers, and what allows this event to occur. Their continuous motion inside our skin allows both sensation and reflection, as they play a central role in every single part of the machinery of life.

Noble soldiers, they also continue to serve even when offered a humble role, when they are given the task to carry away waste, the ashes of the fire of life. Letting the fluid of life carry these wastes outside the body, fertilizing the earth, we should keep in mind that it is a part of ourselves that departs from us, To rejoin the great body of the sea, after a long journey through the depths.

Touching our moist skin, covered in sweat that is the result of the ardor of the sun, or the one of our toil here on the earth, sweat filling the ridges on our fingertips, we feel these countless bits of water taken away by the winds to the heights, carrying with them the excessive heat that burdened the rest of our body, soon joining the clouds that would water the fields of the next harvest.

Thankful for the work of the sky and the efforts of the earth, offering the living the gift of water that allows the fire of life to burn, uninterrupted, we contemplate the vastness of the sea and acknowledge our identity with it.

The song of the waves no longer simply resounds like laughter now. They are also a call, an invitation for a homecoming, a sacred bath in the ocean, a reminder of our origin, of our nature, and of our future, as one day, we also shall return to be fully part of it, our ashes washed away by the rain, through the soil and into the depths, one with the great body of the sea.

Chapter 2

Ingredients of Life: Organic Compounds

The sea is the cradle of life, but no matter how expertly it was built, and how breathtaking it now appears, a cradle is utterly useless before an infant is brought and placed inside it, and when it occurs, the wondrous nature of the creature, infinitely more intricate, mysterious, and awe-inspiring than the one of the cradle, will cause it to be outshined and condemn it to remain in its shadow. There is nonetheless a fundamental difference between this metaphor and the truth of the sea: contrary to the infant, which is formed in the motherly womb and then brought into the cradle, life has been unhurriedly weaved in the sea, the cradle, from pieces brought inside it by the parents of life: the earth and the sky, which impassively toiled to assemble the ingredients necessary in order for their offspring to emerge. The sea is therefore as much a womb as a cradle.

During the age commonly called the late Hadean, that is, around 4 billion years ago, the great sea began to escape the wrath of the sky, which manifested itself as a downpour of large meteors coming from the depths of space to pierce the skin of the earth, regularly vaporizing large quantities of the precious life-sustaining liquid. The planet's landscape was still far more agitated and violent than it is now, with the red-hot blood of the earth erupting all over its face, both over the continents and under the surface of the sea, as an overheated body, ready to burst and spill its vital fluid.

The earth was nonetheless saved by its own weight, which causes this spilled blood to remain on its surface, part of its body, through the action of the enigmatic force named gravity. This same force also allows the breath of the earth to form the atmosphere, the lower skies, which during this time of infancy of the earth certainly were as tumultuous as the land and the sea. The refreshing breeze that caresses our cheeks and lifts up our spirit at the end of the winter was unknown to the Hadean, and no beings were present to experience it. The earth was then unceasingly swept by raging gusts made of a mixture that would destroy our lungs and bring us back to death almost immediately, one mainly composed of ammonia, methane, and carbon dioxide. Behind these somewhat cryptic names, sounding barbarous to the ears of the uninitiated to the science of matter, are nonetheless hidden some of the ore which, once refined, forms the most basic ingredients of life.

The ingredients of life are nonetheless scattered: some of them are carried by the winds across the sky, while others are buried deep into the flesh of the earth. The different ores first need to be mined and gathered before they can serve their purpose. They need to be poured into a crucible and put into contact with the scalding heat of the furnace, so that the hand of the smith can shape them into objects that will represent something more than the material out of which they are made, transcend the nature of the earth. Nature has taken upon itself this burden. Its forces form a labyrinthine and yet perfectly harmonious structure, unremittingly laboring to amass the disseminated substances and carry them into the womb of life. As said earlier, water plays a very important role in this process, but it is not alone. The fiery blood of the earth, flowing in the form of magma both under and above the skin of the earth, contributes to bringing some of the ingredients of life to the surface. The winds cool down this scarlet blood and they carry the watery clouds, which were formed by the sun's efforts, above the dry lands, allowing their water to collect elements concealed into it back to the sea. The various parts of the earth and the sky work together to bring the ingredients of life to the sea, doing so with no apparent will, and yet appearing wholly orderly.

Among the elements collected by the earth and the sky, the one that is the most intimately tied to life certainly is carbon. Like water, its presence on earth in such abundance has not been

clearly elucidated, as in both cases the incandescence of the young earth would have chased these substances away, into the galactic void. The versatile element, which can assume the appearance of a perfectly translucent diamond as well as the one of the darkest soot, would therefore appear to be another gift sent from the deepest skies, as a great mass of it touched the face of the earth once its fiery blush faded away. Its ability to bind itself to four different atoms and even to its own kind allows this element to form large chains, composed of various substances bound together according to a nearly infinite number of combinations. This is one of the reasons why carbon found itself to become the backbone of life, the element forming the scaffold of living things. Bound to four atoms of hydrogen, it forms the inflammable gas known as methane (CH_4), which was one of the main compounds forming the atmosphere of the early earth.

Another fundamental ore from which the building blocks of life can be refined is *phosphorus*, the “light-bearer,”¹ thus named because of the faint glow that it produces when in contact with oxygen. Even though the precise origin of the phosphorus found at the origin of life is still unclear,² this element can be found embedded in rocks, and could thus have been carried by the rain into the ocean or brought up by the currents sweeping its floor. Cloaked with different coats, appearing either waxy white, crimson red, or even violaceous, it plays a low-key and yet crucial role in life, and this is why men who have taken upon themselves the task of helping plants to emerge and grow out of the earth scatter substances containing this element upon the soil, thereby feeding life with it, something more familiarly known as fertilization.

A third important element for the genesis of the precursors of life is the one that fills most of the air that we breathe today: nitrogen (N). It is now present in the sky almost always bound to itself, forming a strong bond with another similar atom (N_2) and thereby rendering it useless to most lifeforms, which cannot make use of it directly.³ The place of this element was nonetheless

¹From the Ancient Greek φωσφόρος.

²See: Alan W Schwartz. “Phosphorus in prebiotic chemistry”. *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 361, no. 1474, Oct. 2006, pp. 1743–49.

³One of the very rare examples of lifeforms able to “fix” gaseous nitrogen and convert it into usable compounds is the bacteria named *Azotobacter*. For more

different during the infancy of the earth, before life sprouted out of it. Probably in addition to the aforementioned molecular form, the sky then also stored another nitrogen-containing compound, one to which we are far less exposed than to the molecular nitrogen of our air, but which is nonetheless more familiar to our senses: ammonia (NH_3). The odorous substance, commonly used to clean the surfaces of our homes, is itself an important precursor of life.

These elements, scattered across the sky, the earth, and the sea, may be gathered together in pools of water, but it is very unlikely that the building power of water, its capacity to trigger reactions, would have been sufficient to assemble these elemental bricks into the building blocks of life. Water is a formidable help to manipulate and invite reactions between substances, but it often lacks the strength to produce, to build new ones. This task would first require an ability to break away what has been built by nature itself, and to separate elements that are already bonded together. Each atom is indeed permanently subjected to the play of attraction and repulsion. When they are found alone, suspended in the vacuum that pervades the space *in-between* all matter, most of them ineluctably crave for a bond with another or others, depending on their own nature, and the same play of forces that is at work within themselves, between their core and their surrounding cloud. For certain elements, to be alone is to be in imbalance, reflecting a lack of equilibrium in their midst. The atom therefore extends its inner strife out of its boundaries. Its inner imbalance must be resolved through an association, an alliance with a substance that would lack what it itself has an excess of, or would provide it with what it lacks. As the lone element moves throughout the medium that it occupies, it will inexorably encounter substances that would satisfy its craving and appease the strife that is tearing it apart. It will bind itself to the first thing that will be able to fulfill its needs, for lack or for excess, as strongly as its nature allows. In order to use these individual atoms, one would then need to be capable of overtaking this bond, of breaking it away by tearing the pairs apart with a pull stronger than their lust for equilibrium.

The edification of matter therefore implies not only to partic-

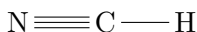
information, see: Hans G. Schlegel and C. Zaborosch. *General Microbiology*. Cambridge UP, 1993. Page 436-445.

ipate in the play of attraction and repulsion but also to be able to wield the strength necessary to overpower the elements with which one intends to build. Such strength will rarely be found among the elements themselves, or even groups of them. Men have now developed such power, but before they stood upon the earth and conquered it with their hands and wit, the larger forces of nature alone were capable of exerting their dominion over the elements and build new substances by breaking up the bonds between them, using the play of attraction and repulsion for the edification of new things. Some of these forces, and their work, will now be briefly examined, as they are responsible for the appearance of the building-blocks of life.

A first example will concern the way by which the sky fixes molecular nitrogen present in the air to form nitrogen-containing compounds used by life. The sky, in its generosity, wielded and continues to wield the forces of nature to dispense some of the nitrogen compounds that the earth and the sea need to nurture life. The celestial storehouse, which does not need walls nor locks to safeguard its content, as the value of this element is locked by the remarkably robust bond it forms with itself and that keeps it up in the heavens, is regularly opened, through an event that represents one of the most conspicuous and intimidating manifestation of the vigor and majesty of the sky: thunder.

The celestial hammer does more than to strike the face of the earth, split rock, turn water into vapor, or ignite the land. It can turn life into death, but it also is found to have played a role in life's inception. Its fury is furthermore not only manifested on the earth and the sea: it principally is directed at the content of the sky itself. When a tension has been built between earth and sky, or different layers of air in the sky itself, the hammer strikes the locks of the celestial storehouse. The elements finding themselves on the path of the lightning are shaken to their core. The lightning bolt slithers in the interstice between the different elements, the space between the clouds surrounding the nuclei that repulse one another, and cleaves the bond between them, thereby tearing the elements apart from their fellows. In the case of nitrogen, each atom is then briefly disunited from its associate, ripped out from the partner that satisfied its yearning for agglutination. Other compounds found nearby, on the path of the lightning strike, share a similar fate and thus, for an instant, a myriad of atoms

find themselves alone. Their inner strife is rekindled and their appetite for communion is growing stronger. When the lightning has faded away, penetrating and vanishing into the depths of the earth, the free elements rush toward one another, expeditiously pairing themselves with the first element or compound that would soothe the quarrel tearing them from the inside, the first substance that would bring them peace and stability, like an addict craving for his poison. Multiple elements can be paired together, forming more elaborate assemblies. Some of the nitrogen atoms will form a triple bond with one atom of carbon, itself bound to one of hydrogen, forming a compound that plays a role in the synthesis of some of the building blocks of life: hydrogen cyanide (HCN):⁴



Thunder is nonetheless not the only force of nature able to break up the bonds between elements. High above the thunderous clouds, far away from the earth, the star filling our eyes with light and allowing us to contemplate the magnificence of the creation also participates in the fabrication of the precursors of life. As a seemingly inextinguishable source of power, the sun's envoys, the rays carrying its strength to transmit it to the matter it encounters, both in the sky and on the surface of the earth, act as miniature lightning bolts. They perturb the equilibrium reached by the stable substances floating in the air of the lower skies, reigniting the play of attraction and repulsion between its different components by adding its own energy to it. The light of the sun can thereby break the balance that kept the substance together, ripping some of its bonds apart and thus inviting the creation of new bonds, with new elements, thereby leading to the formation of new substances, whose emergence would not have been possible without this heavenly intervention.

One example of a contribution of the sun to the emergence of a building block of life is the role it plays in the formation of glycine, an "amino acid"⁵ that is essential to many biological

⁴See: G. Schlesinger and S. L. Miller. "Prebiotic synthesis in atmospheres containing CH₄, CO, and CO₂. I. Amino acids". *Journal of Molecular Evolution*, vol. 19, no. 5, 1983, pp. 376–82

⁵*Amino acids* can be technically defined as a group of molecules composed of a basic amino group (–NH₂), an acidic carboxyl group (–COOH), and an organic side chain.

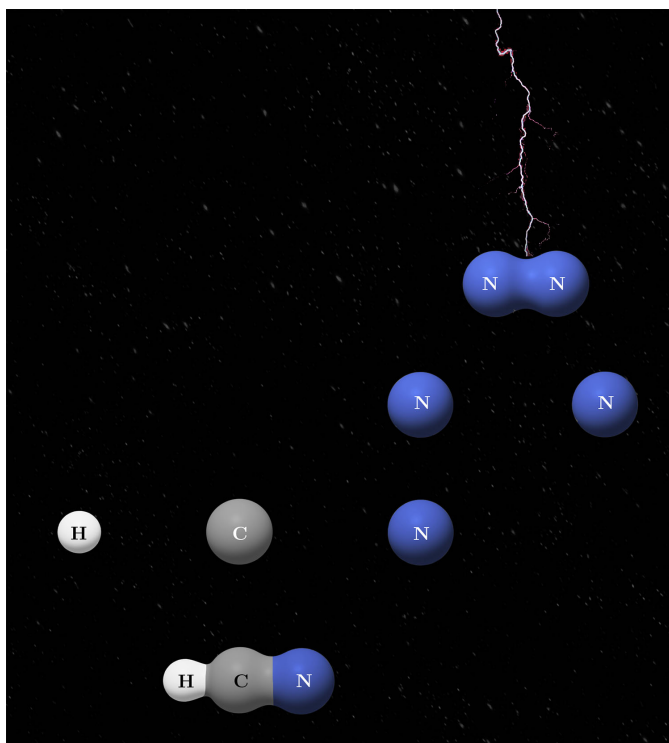
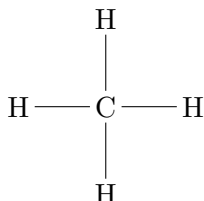


Figure 2.1: *Thunder breaking bonds between elements, here leading to the formation of hydrogen cyanide from molecular nitrogen.*

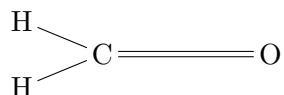
processes, such as the extraction of chemical energy to fuel life or the early genetic code. As said earlier, the lower sky of the young earth contained the gas called methane (CH_4), composed of one atom of carbon bound to four atoms of hydrogen:



The sky nonetheless also contained other substances, among which water can be found, in the form of vapor. This vapor is itself present in the sky due to the agency of the sun: it is indeed because of its rays, which strike the surface of the waters coating the planet, that bits of water are separated from the oceans and elevated high into the sky. Having found an equilibrium by bonding with each other, the constituents of both water vapor and methane have quenched their appetite for attraction. The play of forces in their midst has been calmed, and therefore the two substances have no reason to interact with one another. If one stumbles upon the other, there is only repulsion between them, and each goes its own way. Once again, however, the sun may upset this order by tipping the balance between the elements forming the two substances.

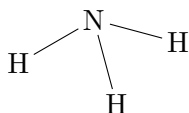
As the radiance of the incandescent celestial body touches the water vapor hovering in the air, it can overpower the bonds between its different elements. The two atoms of hydrogen and the lone atom of oxygen then find themselves separated, and the vapor is dismembered, like a piece of meat cleaved by the knife of a skilled butcher. This immediately rekindles the play of forces within the atoms. The oxygen atom, in particular, is the subject of a particularly intense attraction, a desire for companionship and fusion. Once the sunray's strength has been diffused, it could rebind itself to the free hydrogen floating nearby but it also has other options. Free, naked, and burning for physical contact, the oxygen's desire has been awakened. If it encounters a molecule of methane, it will clobber two of its hydrogen atoms and take their place, tying itself to the rest of the molecule and thereby also changing its nature. Without its four atoms of hydrogen, and with

the addition of the wayward oxygen, it will indeed no longer be methane. It will now bear the name of formaldehyde (HCHO):

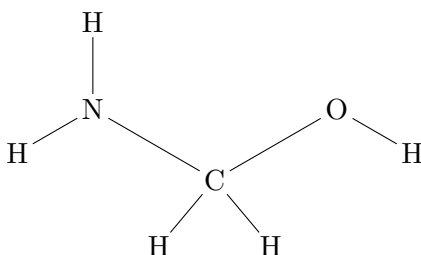


By breaking up vapor into its constituents, the sun provides a spark that would lead to a liberation of energy. It sets some elements free and stirs them up by shaking their inner balance. Because of this, inside the seemingly peaceful and quiet appearance of the clear sky, an invisible and yet large-scale battle is waged. Myriads of freed elements strive against one another, to satisfy their lust for peace, their thirst for fulfillment, like an army of robbers pillaging a village. Vapor fights against vapor, as well as against all the other substances hovering in the sky. Each atom and molecule competes with others, to get rid of what they have in excess and obtain what they lack. Contrary to the lightning strike, which only passed through a tiny portion of the heavens, and this only for a brief instant, the sun is furthermore relentlessly pounding the earth and the sky with its radiance. Only when its face is veiled by the night does the battle therefore cease and the minuscule inhabitants of the sky can find some peace. This peace, however, is only relative. What was set in motion by the sun is not so easily stopped. It can become the starting point of a chain reaction.

Violence invites violence. Action compels reaction, and thus even when the onslaught of the minuscule servants of the sun gives way to the darkness of the night or when its brilliance is concealed by a thick blanket of cottony clouds, the dwellers of the sky continue to wage their tiny war. The recently created formaldehyde soon finds itself face to face with another compound with which it shares the lower skies: ammonia. The odorous gas, which is strongly displeasing to man's nose, is composed of one atom of nitrogen bound to three atoms of hydrogen, according to the following structure:

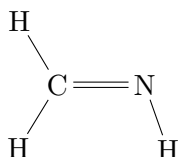


Like a creature with four hands, the carbon atom can hold on four different atoms. In the case of formaldehyde, however, two of these hands are offered to the atom of oxygen, which thereby finds itself bonded to it with a greater strength than to the other atoms. Regardless of this, when the two aforementioned compounds come into contact with one another, one of these hands is extended toward the nitrogen atom of the ammonia. Abandoning one of its hydrogen, which therefore finds itself released, the hand is firmly grabbed by the nitrogen. This bond is stronger than the one that they had before. It satiates their appetite for bonding more completely, explaining why they sacrifice their own nature and revoke the peace that they had achieved with their previous equilibrium. They now find a more stable state, a different way to balance the play of attraction and repulsion inside each atom and between all the atoms with which they are bound. The two substances become one, but once again one that is different than what they were before this encounter, this reaction. The result of this is called aminomethanol (CH_5NO):



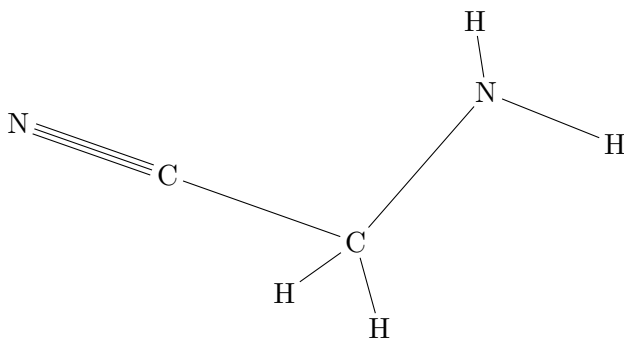
As the resulting compound is a translucent liquid at ambient temperature, it is thus probable that the new substance would come down from the sky and fall down either upon the land or in the sea, the second being more likely as the waters cover most of the earth. The precursor of life is thus offered by the sky to the sea, brought into the cradle of life. This nonetheless does not mark the end of the chain reaction initiated by the sun. The substance is passed on to the great body of water, which also has a role to play in its refining, so that it can be used to create and sustain life. As said earlier, water possesses a structure that makes it almost ideal to manipulate a great number of substances, as its two poles can attract or repel, continuously creating and breaking light bonds with the compounds placed inside the liquid of life.

The army of the sea, the myriad of water molecules, whose soldiers inside a single drop are as numerous as the grains of sand of a beach, thus embraces the newly arrived substance, which came as a gift from the heavens. The aquatic soldiers seize the newcomer and they manipulate it, probing each one of its extremities, to see whether they can react with it, either dismembering it to use some of its parts to add them to their own body or offering some of their own essence to the visitor if it is found to be severely lacking, that is, if its inner strife is severely imbalanced and it is starving for bonding. Almost immediately, an opportunity is perceived. A weakness appears and is swiftly exploited: the oxygen atom of the formaldehyde, which is bound to a hydrogen and a carbon atom, would only need to be briefly separated from the carbon and united to another hydrogen in order to form a new soldier that would join and reinforce the host of the sea. These soldiers recognize their own, and thus pull out the arm of the formaldehyde on which the oxygen is, and it soon finds a hydrogen to be bound to: one of those bonded to the nitrogen of the formaldehyde. A new molecule of water has been added to the ocean, but the compound from which it was formed finds itself crippled. The carbon atom that was bound to the oxygen finds itself lacking. One of its four hands hangs in the void, seeking to attract another atom, which would also be in need of a new bond. Fortunately, the nitrogen which is already bound to it has also been deprived of one of its allies, the hydrogen that was used to form the new water molecule. The two atoms therefore both extend their free hand toward one another, thereby doubly binding themselves to one another. Once again, the play of attraction and repulsion is then calmed and the balance between the two forces is, momentarily, restored. The new substance emerging from this work of water is called methanimine:

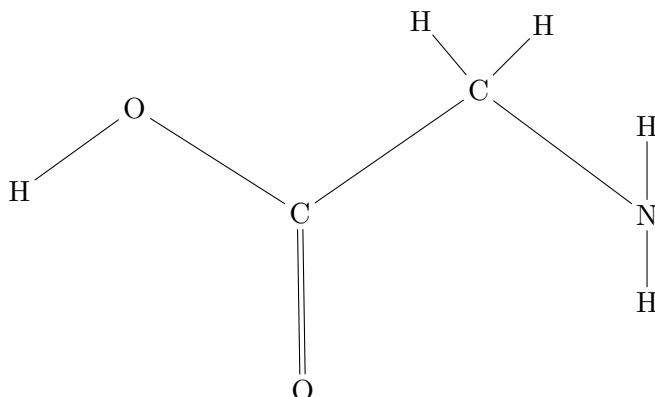


The aforementioned reaction shows that nature sometimes first needs to break in order to build. It needs to take away to make way for something new that will later be constructed. The chain reaction has indeed yet to end. The new compound will now

run into another, the one that emerged following the action of the first force of the sky that we mentioned earlier: thunder. Hydrogen cyanide indeed finds its way into the sea, coming down from the sky in which it was born, and when it is brought into contact with methanimine by the soldiers of the sea, the carbon atoms found in each compound find a greater affinity between themselves than with the hydrogen atoms to which they were bound. The lighter, weaker element is then once again momentarily cut loose, and the two fellows attach themselves to one another, thereby joining the two compounds, before the hydrogen finds a new place. What emerges from this reaction is aminoacetonitrile:



Finally, water will bring a final touch to this work of edification, paving the way for the emergence of life. The sea will not hesitate to sacrifice its own soldiers to perform this task, executed naturally by the force of nature, as the newly formed substance is found to thirst for water. One of the carbon atoms of the fresh substance indeed craves a bond, and thus the sea offers two of its soldiers to provide it with what it needs, oxygen in particular. Then can its instability be resolved. Then only can its inner conflict be calmed. As two water molecules are mutilated and their members used to appease the compound, what is then formed is at last one of the building blocks of life, one of the amino-acid used to build proteins, the machinery that power all forms of life, glycine:



The genesis of this substance, which represents a letter with which parts of life are written, a character of the language of life, therefore demands that bits of matter take a relatively long and sinuous path. It involves the partnership of some of the greatest forces of nature that we can experience: the sun, the sky, thunder, the sea, and others. These forces nevertheless do not seem to have been endowed with a will of their own, and if they are themselves the hands of a higher will, this directing force itself remains concealed behind the canvas forming the very fabric of the universe, behind the laws appearing to reign over space, time, and matter, that is, the earth and the sky.

When it is observed in isolation, the course taken by the bits of matter to form a somewhat sophisticated compound such as glycine, which is only the simplest of all the amino-acids forming proteins, may appear almost miraculous, inviting us to see it as being willfully formed by the hands of nature. The work of the forces of the earth and the sky is nonetheless different than the one of man. It forms a whole, unfocused and without direction. It acts as a drop of ink on a piece of blotting paper, slowly diffusing itself, exploring every single path that is offered to it, simultaneously extending itself in every direction, until it has exhausted its own strength, has stretched out its essence to its limits. The precious precursors of life are relentlessly produced by the conjoint work of thunder, the sun, the earth, and the sea, but the work of nature also forms countless other substances. In fact, it forms every single substance allowed by its structure, that is, by what is usually called “physical laws.” The forces of nature diligently explore every single possible reaction between the elements forming the body of the

earth or those floating in the sky or the sea. They break and assemble, tear apart and bring together, but a large part of what they fabricate simply decays. This nonetheless does not make it vain.

A gold panner must inspect and throw away prodigious quantities of earth in order to find a nugget, and in the same manner, nature systematically explores all the possible reactions between elements and molecules. Functioning as a harmonious chaos, a perfectly ordained torrent of seemingly random interactions, this process of creation, of edification of new substances is nonetheless counterbalanced by the very scaffolding of the universe, which acts as a sieve sorting out what is rare and precious. The rules dictating the structure of atoms and the way these can be bound and react with others are the furnace in which the ore can be refined. What is unstable, unable to resist continuous collisions with other substances, the blows of the sun's envoys, or being carried by the soldiers of the sea, simply wither away. Others nonetheless resist the trials of the earth and the sky, and the unceasing onslaughts of other substances, which try to tear them asunder, dismembering them to use their parts for their own edification.

The newly formed substances are therefore made to compete, pitted against one another by the forces of nature, like gladiators thrown into an arena, where only the strongest will survive. A selection thus occurs. The body of the vanquished decays and is used to try new things, creating new candidates who will also be tried in the arena. One is nevertheless never safe inside it, as the flow of new combatants is continuous. Thanks to this remarkably simple and yet unostentatiously refined mechanism, more and more complex substances can emerge from the chaos of the earth, the sea, and the sky. The realm of matter can be edified, built to increasing heights of sophistication, stability, and diversity.

The secret of life is like an incredibly complex lock, requiring a perfectly fitting key to be revealed. Fortunately, nature had the time to make and try out an astonishing number of them, not needing wit nor will, but rather only the brute force of the earth and the sky, the reunion of matter, space, and time. The manifold nature of the environment of our planet has provided the means necessary for the discovery of the key of life. The frontier between domains ruled by different forces appears to have been

the crucial locus of this work, that is, the place exhibiting the starkest contrasts, the greatest tensions, which provide the energy necessary for complex reactions to occur. The places where the fiery blood of the earth is poured into the icy seas, technically called “hydrothermal vents,” are one example. Shallow networks of pools where different compounds can be concentrated may also provide a tension allowing the generation of new substances. The atoms and molecules found in one pool may indeed be imbalanced, with either excesses or lacks of force in their core or surrounding clouds, craving for bonding, causing them to be slaves to the play of attraction and repulsion. When two of these pools are brought into contact, through the work of the moon known as tides, for example, a great transfer may occur. A strife is then kindled as each element tries to satisfy its lust for equilibrium, seeking the taming of the conflict taking place in their midst. Such events are the occasion of a great release of energy, which can facilitate the emergence of new substances and contribute to the edification of the earth, seen as the realm of matter.

During the later part of the eon preceding the appearance of life, the exploration of the possibilities offered by earthly materials therefore began. The entirety of the earth and the sky became a field of experimentation, where a prodigious number of reactions were tried. The sun continued to pierce the air during the day, and the winds scattered the products of its work all over land and sea. Some spots were found to be more fitting than others to edify new materials: those offering the right conditions, such as heat or cold, moisture or dryness, light or darkness, or the availability of particular elements. Supply is indeed also crucial, as only when a sufficiently broad choice of elements and compounds are readily available can new substances be formed efficiently. This is why the middle of the ocean may not have been an ideal place for the discovery of the key of life. Pools of water, with access to the sea through tides and a shallowness allowing their water to be extracted and taken up in the air by the sun during the day, may have allowed greater concentrations of particular compounds, and therefore stimulated new reactions.

One thing should nonetheless be kept in mind: the conditions leading the forces of nature to discover the key unlocking the secret of life may have been unique to the end of this eon. If life were to be extinguished from the earth, the present conditions experienced on

our planet may prevent a rediscovery of its secret. The unlocking of the secret of life occurred as a conjunction, a meeting between the earth and the sky at a particular point of their development on the one hand, and a group of elements present in their midst on the other. The two were inseparable: the new matter built by the forces of nature inextricably remained part of the earth and the sky, and the fruit of their work, in turn, began to shape them. The chain of reactions slowly transformed the land, the sea, and the air, prefiguring the birth of a new force of nature, which would soon be shaped from the new compounds selected by the very frame of the universe, the laws governing the interactions between the elements.

The discovery and production of the most elementary building blocks of life nonetheless only represent the first step toward the discovery of the key of life. These bricks will need to be assembled together. Larger things will have to be built, and their architectural soundness will have to be tested, just like the smallest compounds before them. The key of life is indeed one of tremendous complexity and elegance, and the forces of nature will have to relentlessly toil for entire ages to discover it.

Re-flection: The Matter Within Us

Our eyes raised toward the vastness of the heavens, we contemplate our origin, the source from which water, the backbone of our life, came to the earth, in a violent collision that brought ice where there was fire.

The dark chunks of coal that warm us, or the crystal-clear diamond worn on a finger, their essence also traveled through the cosmos before crashing down to sow seeds of life. It is a catastrophe turned into a miracle, the gift of an unknown, remote sender, as this essence is also ours, the scaffolding of our entire body, pillar of our world.

Replenishing our lungs with fresh air, letting the heavenly ether flow into our chest, the earthly nature of the air is brought to our attention, as a soft, invisible caress of the sky. This celestial fluid is replete with myriads of particles, hidden behind a veil of transparency. Allying the delicate softness and volatility of ashes with the clearness of a diamond, these bits of matter, this air, is meticulously turned into life by the plants, and then into the flesh of man. This heavenly breeze is one of the sources of our skin, blood, and bones, one of the mines from which life extracts the ore from which our bodies are built.

Letting our eyes be filled with the fiery radiance of our gilded star, and opening our ears to the monstrous roar of thundering clouds, we acknowledge the work of the heavenly forces that, patiently and selflessly, weaved the first building blocks of life by stirring up the air, the sea, and the earth. These eyes and these ears, they would not exist without the relentless labor of these forces. The elements forming these fingers would be scattered across the earth, and no one would be present to praise the wondrous vigor of nature.

From the most insignificant part of our flesh to its most vital elements, each substance forming what we are is a vessel built by the forces of nature. Each chain of atoms is a witness of the work of the heavens, and every part of ourselves stores within itself the fiery wealth of a star, the bright resplendence poured by the sun onto the face of the earth. This wealth, this gift, may nonetheless at all times be taken back, as a thunder-strike may dissolve the bonds between the parts of our flesh, thereby quenching the fire of

life burning within our chest.

The sky is nonetheless not alone to give and take away, to build and destroy. Taking up a stone into our hand, or lying down on a rocky part of the land, we feel the cold embrace of the earth, contrasting with the fire of life within us. As much as with the air, we share a common nature with parts of this rock. Minute parts of the craggy crust of the planet found their way into the rivers, into the water we drink and the food we eat, and found a place in life.

The strength of our bones is borrowed from the minerals coating the earth, and our muscles would remain motionless without their contribution. We are the sons of the earth and the sky, the offspring of a marriage of forces, combining and uniting the realms above and below, sharing their nature. We bring the heavens down and elevate the earth, being neither of them, and both.

Now enjoying the hospitality of the earth and the bountifulness of the sky, we nonetheless should remain mindful of the origin of the building blocks of our being. The gloomy landscape of the young earth may not have filled our eyes with wonder, and its noxious air would have inspired us horror if we were to breathe it, but when the pungent smell of the watery fluid excreted from us reaches our nose, we may still recognize in it one of the foundation stones of life, one of the substances that filled the air and helped kindle the first spark of life.

Every day of our lives, we are surrounded by innumerable bits of earth, floating in the air, carried by the currents of the sea, or resting in the soil. At every breath we take, at every bite or sip, we trade parts of ourselves, hoping to remain, for a little while longer, above rather than under the face of the earth. Constantly exchanging with the forces of nature, the delimitation of our being is blurred. The boundaries of our self are immanent and evanescent, imitating the ever-changing whole. Our senses nonetheless remind us of what we are, as they set the limits of our experiences, even though what is sensed is not always distinguishable from what senses.

Chapter 3

The Opening of Life: Self-replicating Molecules

Even though man now has a decent grasp of the way by which life grows and functions, its origin is still largely shrouded in mystery. All that we can do, for now at least, is speculate concerning the event that, soon after the shaping of the earth by the hands of nature, brought on the monumental chain reaction leading to a radical transformation of the entire surface of the earth and to our birth into this world. Uninterrupted for billions of years, this chain reaction would appear to represent the single most complex process in the known universe and yet, considering the wondrous intricacy of life, the principles underlying and directing it may sometimes be disconcertingly plain and elegant. Governed by the simple play of attraction and repulsion between the smallest pieces of matter, according to different “forces,” different dimensions, the earth and the sky are building increasingly complex things. With each revolution of the earth around the sun, new substances are cooked in the great cauldron containing the seas. The strength of the yolk-colored star nourishes the development of these new forms of matter, as the hands of the sea selflessly work to refine what has already been produced, which then reaches new heights of complexity and stability.

Many things remain unknown concerning the origin of life, but the observation of the ways of nature teaches us that it would seem to be the result of an exploration, by the forces of nature

themselves. The scaffold of the creation, the fundamental structure of the universe, which is invisible and still largely unfathomable to us, provides a mold in which matter can be poured to form different things. The mold is always present, but only when matter reaches it can its shape be seen, and its nature recognized. The work of the forces of nature is to guide matter into the ridges and the holes that are waiting to be filled and appear, but it is not as simple as pouring paint on a canvas. The structure of the mold is intricate and delicate, demanding patience and repeated trials before its parts let themselves be filled and revealed. The scaffold of the creation is a surface made of countless locks, while matter and the forces shaping it respectively represent keys and the hands forging them.

The emergence of each new substance brought on as the result of the play of attraction and repulsion by the forces of nature represents the opening of one of the locks of the creation. It is a dis-discovery: the unveiling of something that was already existing, but only covered and therefore invisible. The fabric of the universe already contains all the possible substances that could be formed with atoms, but only when the right combination is found by nature can they appear and *be*. The realm of all the possible substances is indeed not identical to all the imaginable combinations of atoms, as the very structure of the universe would prevent most of them from existing. This is why nature is patient in its work, as any edification demands conformity with a set of rules, the invisible scaffold. The forces of nature cannot invent, but only dis-discover, un-lock.

If there is a secret to the wondrous nature of life, it would therefore be found in the very architecture of the universe rather than in any particular combination of pieces of matter. The key of life should be searched, but one should nevertheless not expect it to be extremely peculiar, to ostentatiously stand out from the rest of the creation. The dis-discovery of the key of life would not break the spell of its mystery, but rather only invite us to contemplate the entirety of the horizon of nature. Before considering this, one must nevertheless first take a glimpse of the key of life itself.

3.1 The Key of Life

As when painters decorate offerings,
 men well trained by wisdom in their craft,
 who when they grasp colorful chemicals with their hands,
 mixing them in combination, some more, some less,
 from them provide forms like to all things,
 creating trees, men, women,
 beasts, fowls, water-nourished fish,
 and longlived gods foremost in honors.
 So do not let deception overtake your wits that from
 somewhere else is the source of mortal things, all the
 untold many things that have been manifested, but
 know these things clearly, having heard the tale from
 a god.

— Empedocles¹

The key of life has at least once been dis-covered by the earth and the sky, as both joined their forces, stirring up the air, the sea, and the dust, to give birth to a third realm, caught between them both. Once it had unlocked the first door of life, this key was transformed, reshaped into another, and its original form fell into oblivion, once again concealed and unseen. We, the pinnacle of this third realm, have explored the paths taken by our forefathers, from the one of our close parents until the one of the very first forms of life from which we descend, but the first key still eludes us. We do not know what exact assembly of earthly matter kindled the first spark of life. The firestone has yet to be unearthed. The gap in our knowledge of the origin of life is nonetheless not too important as to prevent us from getting a vision of how the giant chain reaction, the fire burning through the ages that is life was

¹From: Daniel W. Graham. *The Texts of Early Greek Philosophy: The Complete Fragments and Selected Testimonies of the Major Presocratics. Part 1.* Cambridge UP, 2010. Page 359. Original Greek: “Ὡς δ’ ὁπότεν γραφῆες ἀναθήματα ποικίλλωσιν ἄνδρες ἀμφὶ τέχνης ὑπὸ μῆτιος εὖ δεδαῶτε, οἷτ’ ἐπεὶ οὖν μάρψωσι πολύχροα φάρμακα χερσίν, ἁρμονίῃ μείξαντε τὰ μὲν πλέω, ἅλλα δ’ ἐλάσσω, ἐκ τῶν εἶδεα πᾶσιν ἀλίγκια πορσύνουσι, δένδρεά τε κτίζοντε καὶ ἄνδρας ἡδὲ γυναικας θῆρας τ’ οἰωνούς τε καὶ ὕδατοθρέμμονας ἰχθῦς καὶ τε θεοὺς δολιχαίωνας τιμῆισι φερίστους· οὕτω μὲν σ’ ἀπάτη φρένα καινύτω ἄλλοθεν εἶναι θνητῶν, ὅσσα γε δῆλα γεγάκασιν ἄσπετα, πηγὴν, ἀλλὰ τορῶς ταῦτ’ ἴσθι, θεοῦ πάρα μῦθον ἀκούσας.” from: Graham, *The Texts of Early Greek Philosophy. Part 1.* Page 358.

ignited. All the pieces of the puzzle are now within our reach, and even though a few pieces have yet to find their place, the great picture can already be seen, and this is what should matter to those who peer into this subject to better perceive their own nature rather than to acquire mere technical knowledge.

What is clear is that life finds its origin in an extremely laborious work undertaken by the earth and the sky, with an astronomical number of possibilities relentlessly tried during entire ages, until one day, when all the pieces of the puzzle fell into place. Compounds based on carbon, nitrogen, oxygen, and hydrogen, among others, were patiently assembled by the sun, the winds, thunder, the sea, the rocky earth, and even perhaps the moon due to its role in the movements of the sea. As a result, the “amino-acids” that were examined in the previous chapter were discovered by nature, substances that form the basis of proteins, pieces of the machinery of life, but also another kind of molecules, technically called “nucleobases,” or simply “bases,” which form the language by which most life is written, also known as the genetic code. Before the emergence of the first forms of life, it would nonetheless seem that these molecules were simply the ingredients of what has commonly been called a “primordial soup,” a part of the sea where they could be found in great concentration and could react with one another, following the guidance of the earth and the sky.

At one point, the forces of nature discovered a new possibility. They opened up a new space where they could express their skills: the opportunity to assemble amino-acids and bases into chains of relatively arbitrary length, thereby greatly facilitating the creation of complex compounds and therefore also exploring new types of substances, through a reaction technically called polymerization. All that is needed is the binding of a common structure to the base, one that would be in turn enclined to form bonds with its peers, bonded to other bases. It was not necessarily the case for the first forms of life, but this chain is now often based on the association of a sugar called ribose with a phosphate, both of which can be naturally produced, without the help of life, and the resulting structure can be seen on Fig. 3.1. This chain links the bases together, like a line on a piece of paper, where characters can be joined to form words and sentences. An almost infinite number of sequences of bases can thus be created, but at this point, the language of life has yet to itself be unlocked by the earth and the

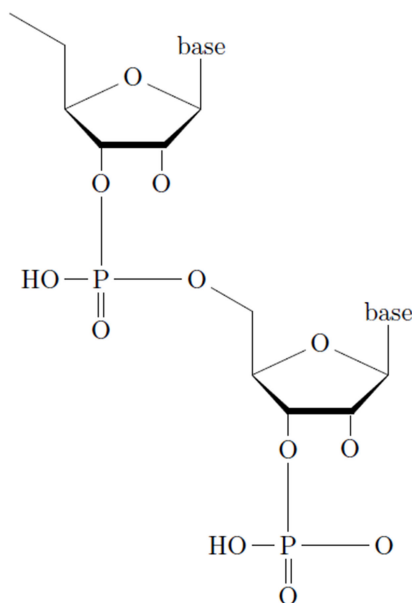


Figure 3.1: *The chain structure of a chain of bases (RNA, Ribonucleic acid).*

sky. A piece of paper and some ink is not enough to produce a book. The mastery of the alphabet is insufficient to become an author, and for now, nature has yet to dis-cover the hidden power of these tools. It nonetheless perseveres, and we know it eventually succeeded.

For now, the bases are meaningless signs, a juvenile scribbling, the darkening of a piece of white paper according to chaos, but the possibilities offered by the chains and bases are nonetheless being explored. Such work can be performed by the forces of the earth and the sky: it has been shown that a chain of bases can indeed be formed through contact with particular materials and an alternation between wet and dry conditions,² such as the ones caused by the daily revolving of the earth upon itself and the veiling of the sun associated to it, or the tides of the sea, commanded by

²See: Sidney Becker, et al. “Wet-dry cycles enable the parallel origin of canonical and non-canonical nucleosides by continuous synthesis”. *Nature Communications*, vol. 9, 11 Jan. 2018

the moon, which can bring moisture twice a day to a shore dried up by the fire from above.

More than skillful hands or even mere luck, nature used its greatest strengths to unlock the secret of these new materials: first, its patience, as it can afford to spend entire eons on the opening of a single lock, and also its vastness, as it can perform myriads of experiments and trials at the same time, simultaneously working in the four corners of the earth, in the highest skies and the deepest seas, with the raw brutality of thunder or the tenderness of water, in order to find new keys, opening new spaces that nature can invade and occupy.

Many different substances may be joined into long strings by the use of the aforementioned chains: amino-acids, bases, and many others. One peculiarity of bases nonetheless makes them particularly significant: the fact that each one of them has a special affinity with another. If placed together in close proximity, they will tend to pair themselves with another kind of base, and only one of them. The very three-dimensional structure of the bases makes them almost ideally suited to be bonded with another, because of the same play of forces that led to the formation of the bases themselves. Some parts of a base are imbalanced: the cores of the atoms composing it are either under the yoke of surrounding clouds, or they overpower them. They either have lacks or excesses, and the play of attraction and repulsion demands that these be resolved, and an equilibrium reached, when possible.

One side of each base shows a pattern of lacks and excesses that well complements the one of another kind of base. Like a lock and a key, the two can find themselves fitting one into the other, thereby also calming the inner strife that raged within each molecule. One example would be the pairing of the aforementioned base, *guanine*, with another, named *cytosine*, as shown in Fig. 3.2. Here, three atoms on each base display a complementary pattern of lacks and excesses, represented by colors, and thus the two bases attract one another, fitting in one another in a particular position, which is unique. Such a pairing would not occur with other bases, and thus each base has a single kind of partner with which it can be bonded. This bond is nonetheless a rather feeble one. It does not involve a fusion between the two partners, but rather only a slight contact and retention. Each one of them remains what it is,

distinct from the other, and the interaction between them is like a dance or an embrace. They are ready to let go of their bond at any moment, if they are pulled away by a stronger force.

From the remarkable and yet simple ability of the bases to pair themselves with one and only one of their peers, a new and important property of matter can then be revealed. When a chain of bases is found floating in a mass of water replete with other bases and the molecules necessary for the formation of new chains, each base of the chain will attract and bind itself to its complementary base. On one side, we have the bases as dancers holding each other with one hand, forming the chain, but on the other, we have other dancers, freely roaming alone through the water, rushing to find a partner. Some form couples with other free dancers, but some take one hand of those forming the chain and hold it tight. When all the members of the chain have found a mate, the chain has grown thicker. The dancers forming the new half of the chain nonetheless still have one of their hands free. They are not attached to one another as those on the other side.

If the conditions are just right, and these unfortunately have yet to be (re)dis-covered, the reaction that led to the formation of the chain may once again occur, bonding the newly found bases together, forming another chain, parallel to the first. Once again, the forces of nature are therefore needed to perform this task. It probably took countless years of trials and failures, but nature one day succeeded. This event may have taken place in shallow pools bathed by the sun and filled with the tides, or in small cavities near the places where the earth poured molten lava into the icy sea. The conditions allowing this reaction may only have been possible at a precise point in the history of the earth, as a conjunction of a formidable number of fortunate interactions, or it may have been rather direct and simple. The secret of this event is still well kept, but it should not matter so much to us, as we can see the result, and already perceive the nature of this crucial event in our history.

The bond between the two chains is weaker than the one uniting the different links composing them. Each chain is like a series of pieces of cloth, sewn together with a robust thread and numerous stitches, and the bond between them is like two pieces of fabric brought together with a few buttons. If one pulls the two pieces apart, the thread of the buttons will break before the cloth

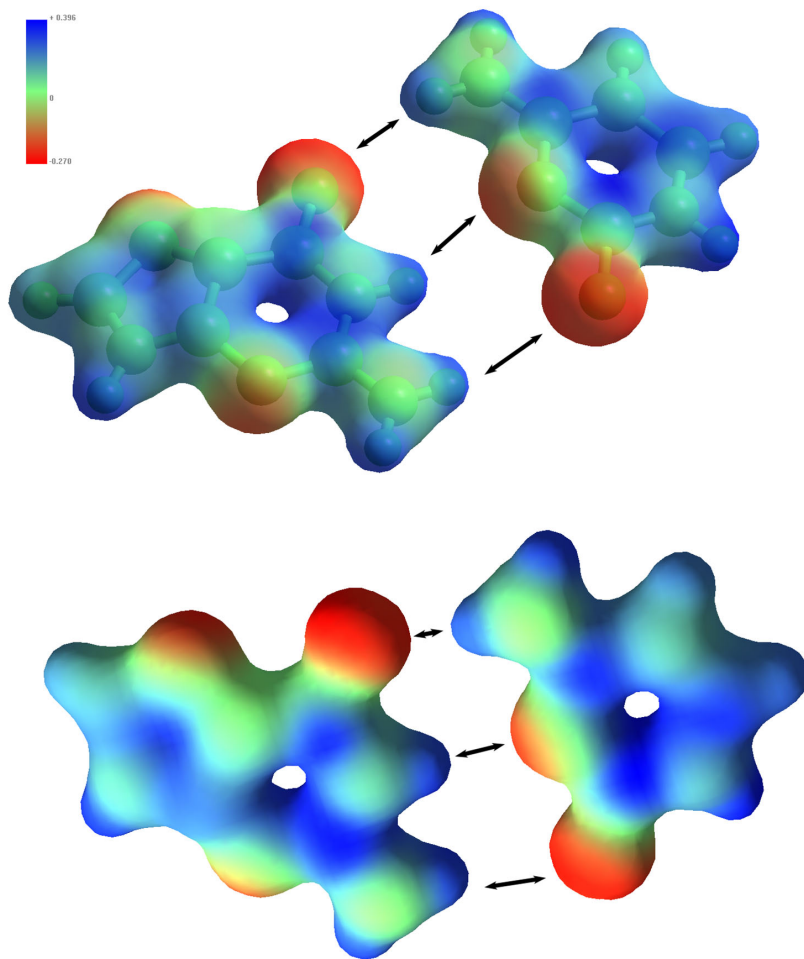


Figure 3.2: *Pairing of guanine and cytosine (electrostatic surface).*

is rent. The hands of the servants of nature will be prompt to try to separate the two chains, to break the couples of dancers holding themselves with a soft grip. The fires of the earth and the sky would both be able to perform such a task. The fiery blood of the planet, spilled by volcanoes above the land or in the entrails of the sea, could bring the water in which the chains are floating to the boiling point, making each particle contained in this water vibrate furiously. The same could be done by the sun, with a more superficial reach, as it would not penetrate the depths of the sea but nonetheless possess a far broader range, since it could at every instant cover half of the surface of the earth. For each base of the chain, it would be in both cases as if they were forced to enter into a trance, chaotically moving up and down, to and fro, until they release the hand of their partner and find themselves carried away by the impulse induced by their fever. The frenzy brought on by the heat of the earth or the sky would nonetheless often not be sufficient to lead to a release of their other hand, that is, to the breaking of the bonds forming the chains themselves. When this occurs, the two chains then find themselves separated and carried away by the army of the sea, the water molecules that unceasingly bring together, disentangle, or haul away the matter that comes within their reach.

Once the two chains find themselves isolated, and the fever that led to their separation has been calmed, the marvelous nature of the event can then be perceived. The new chain represents a mirrored copy of the first one, like the imprint left by a hard object on watery clay, sand, or plaster. If the original chain represented a line written in a language whose characters were molecules, the new one could be seen as containing the same *information*, only written in black on white rather than white on black. The imprint of a seal is the exact opposite of the seal itself, and it is precisely because of this exactitude that the eyes recognize both of them as representing a similar image. Likewise, the correspondence between the base pairs leaves no ambiguity: if one sees a *cytosine* base on the second chain, one would be right to suppose that its partner was a *guanine* base on the first chain.³ Information has thus been reproduced during the event that led to the generation of the new chain. This, however, is only a beginning.

³There are, of course, exceptions, which will be discussed at a later point.

The two chains indeed find themselves once again floating in a bath of bases and other substances. Each one of the members of the chains again finds himself in need of a new partner, to dance to the same tune as before. The same event repeats itself. The same causes produce the same effects, and two new chains are then produced. In this case, one peculiarity nonetheless can be noticed: when the second original chain is reproduced, it is identical to the very first one. The imprint of an imprint of a seal will be in all points similar to the original seal. By complementing two times the bases of a chain, the original one has been exactly reproduced.

With the help of the forces of nature, and a fitting environment, a complex substance can thus reproduce itself. This represents the first key of life, the discovery of the ability of an elaborate assembly of matter, ordained according to a precise structure, to make copies of itself, an event that would preserve their common nature, even when the original molecule would have ceased to exist. For now, the sequence of bases forming the chain that is reproduced is largely random, the result of the work of countless hands, mainly those of the soldiers of the sea, the molecules of water that brought the bases to their partner, as they were themselves subjected to greater forces such as currents and tides. Out of this apparent randomness, an order will nonetheless soon emerge. Arbitrariness will be replaced by information. Coincidence will be supplanted by coherence, without the need of a *deus ex machina* that would precisely manage these events. If a god there is, it would seem that it is to be found behind the fabric of the universe, as its architect, rather than as a master-builder toiling inside of it.

The first key and the opening toward which it leads nonetheless is just a first step. The self-reproducing molecule would not fit most definitions of life yet. The spark of life must first be kindled into a fire. The reactions leading to the reproduction of the molecule must be able to be sustained.

3.2 The Kindling of the Fire of Life: The Great Chain Reaction

The formation of the chain of bases and its reproduction described in the last section demands the fulfillment of an extraordi-

narily lengthy set of conditions. One of the most difficult aspects of such a reproduction mechanism, occurring naturally before living organisms were present on the earth, is the “stitching” of the newly paired bases into a new chain. Life, as we know it now, no longer reproduces in such a manner. It now relies far less on the forces of nature and more on itself. It uses specialized molecules, proteins formed of long chains of amino acids, which take care of the tasks that were at first performed by the hands of the forces of nature: the “stitching” of the bases forming a strand or the separation of the two strands following the pairing, for example. The emergence of such a piece of machinery represents a second key of life.

One of the properties of long strings of atoms and molecules is that they will tend to naturally fold on themselves. When they do so, they not only represent one-dimensional lines, where a limited number of characters are written, but also three-dimensional objects, whose structure is directly correlated with the particular sequence forming this chain. This folding once again occurs because of the play of attraction and repulsion between the different parts of the chain. The parts of it where the nuclei are stronger than their surrounding clouds will tend to be attracted and lightly bond themselves to the parts that know an opposite imbalance of power, and vice versa. The three-dimensional structure resulting from this will itself display the same kind of disequilibrium, only on a larger scale and according to a more complex shape. As such a structure can comprise dozens or even hundreds of atoms, the grain of the pattern of attraction and repulsion that it provides can be extremely fine. Furthermore, such structure is not necessarily rigid: each atom forming its outer layer may interact with other substances with which they can be brought into contact. The structure may thus find itself transformed by such interactions, leading it to become animated, continuously moving.

The shape of a chain may therefore reveal new powers. A seemingly random two-dimensional line of bases may be found, once it has been given the opportunity to fold itself, to form a complex piece of machinery, able to replace the forces of nature for certain tasks in the edification of life. Its shape, the pattern of attraction and repulsion associated with it, and the capacity of some of its components to react with other substances, allow it to manipulate matter, to induce reactions, to create and destroy

bonds, to carry or to tear apart. Chain of bases, such as RNA (ribonucleic acid), may form such machines, and perhaps were the first to do so, even though most of such working molecules are now proteins, that is, chains of amino-acids.⁴

The shape taken by a chain nonetheless demands particular conditions: as the envoys of the sun could rip apart two chains bound together by the pairing of their bases, they can just as well unfold one of these molecular machines, rendering it largely powerless, but the effect of heat or cold may also broaden its functions. As it assumes different shapes according to different environments, it may therefore also perform various tasks. Able to reproduce at certain times, certain temperatures, it could also do something else when a change of environment occurs. The cycles of the sky, whether it is those of our star or those of the moon, such as the risings of the sun, the tides, or the seasons, may therefore continue to play a crucial part in transforming the newly constructed piece of machinery.

To the human eye observing the intricacy of the work of nature, the order of things may appear perfect. This perfection nonetheless includes the necessary presence of imperfections, mistakes, and randomness that, while they may be perceived as breaking the neatness of the creation when looked at in isolation, in fact represent its pinnacle. One example would be the “errors” that will almost inevitably occur during the self-replication of long chains of bases. The pairing between two bases indeed depends on the fitting of a part of a base with another, which possesses a complementary pattern of attraction and repulsion, lack and excess. This pattern is nonetheless rather simple, and in the case examined earlier, centered around only three points, like a key with three notches. In the large majority of cases, each base will successfully be paired with its complement, but other molecules may have a pattern sufficiently resembling the one of a base so as to usurp its place. The resulting chain would therefore differ in this location from the original: a *mutation* occurred.

The first chain that succeeded in reproducing itself may have

⁴Proteins would not be able to reproduce as chains of bases could, as their building blocks, amino-acids, would not efficiently pair themselves like bases would. This is why they are usually not considered to be the first building blocks of life.

had a dozen or billions of identical offspring. Once the key had been found, once the spark was lit, the new kind of matter, the first child of the earth and the sky born in the sea, would propagate itself like fire. Colonizing the waters with its kind, it nonetheless remained incredibly powerless, incapable of surviving outside of a narrow territory providing a very precisely tuned environment. Prisoner of its cocoon, and unable to change, it hardly fitted the description of life as we know it. This embryo of life was then stuck on a single path, itself a dead end. Its course was set and it was powerless to deviate from it. The very scaffold of the earth and the sky, the most fundamental structure of the creation, nonetheless already had a way out planned, a trap door waiting to be discovered.

When a pairing with molecules other than their complementary bases occurs, the chains are offered an opportunity for change, a chance to gain their own identity, differing from the one of their parent and siblings. It is as if a pebble was thrown on the course of a train, causing it to leave the rails on which it was put and allowing it to explore a new, untrodden path. The fire growing in the sea then begins to be tainted with different shades, reflecting the growing variety of the substances composing it.

The deviation induced by a single mismatch may not appear significant, especially if a chain has hundreds or thousands of bases, but considering the fact that a single chain may produce an astronomical number of offspring in a relatively short time, and that the reproduction cycle may continue for millions of year, its accumulation would quickly grow and potentially radically change the nature, shape, and properties of the resulting chains. Through this mechanism, new keys can be discovered, new locks can be opened, and the exploration of countless new paths can be undertaken by the chains.

Before the fire made of the self-replicating chains may be legitimately called life, one element is nonetheless missing: the ability for the chain reaction to sustain itself, without complete reliance on the help of the forces of nature, such as the tides or the alternation between night and day. Fortunately, this is precisely one of the problems that can be solved by the chains themselves, now that they have been granted a certain degree of freedom and have begun to explore the realm of the possibilities offered by their nature, as long chains of bases.

The manner in which the chains solve the problem of the sustainability of the fire of life is now relatively well understood, but what largely remains a mystery is how was this first accomplished, the intermediary stages leading up to it. Thanks to the power of transformation of their kind derived from random mutations, the chains developed different abilities. As innumerable paths were explored by them, while an exponential number of sequences of bases were tried, new keys were found. By folding themselves according to particular shapes, with different patterns of attraction and repulsion, the chains discovered the capacity to themselves produce the machinery necessary in order for them to cease to be so dependent on largely unpredictable natural events for their reproduction.

After countless trials and generations, some of the chains developed a new talent: parts of the sequence of bases composing their body, forming limbs extended outward, could trigger series of reactions leading to the production of chains of amino acids, proteins, which could perform specific tasks. Not part of the chain of bases itself, they could even operate on multiple chains, assisting them in their replication. An essential role of these little chemical “creatures” would be to replace the natural forces that provided the strength, the energy necessary for the breaking and forming of bonds between atoms and molecules, something necessary for the assembly of the components of the chains from elements commonly found in the sea, the bases themselves and the elements forming the backbone of the chain, in particular. Contrary to the chains of bases, proteins can harvest the forces embedded in some molecules and elements. Some can integrate the envoys of the sun and exploit their force to fabricate new compounds, which can then be offered to their creator, the chains of bases.

The discovery, creation, and subjection of a set of peculiar proteins by the chains of bases is a decisive event. It may be seen as the line separating random sequences of molecules that possessed the ability to be replicated by the forces of the natures from the first living things. The fire extending itself in new parts of the sea may now deservedly be called the fire of life.

Having created and manufactured servants able to reliably replace the hands of the earth and the sky for their own reproduction, the chains of bases can now take greater independence from their

parents. They no longer need lightning strikes tearing up the sky to form their building blocks. They no longer need the fiery celestial orb or of its silvery cousin to assemble their backbones. These tasks will now be performed by their servants, empowering them further and allowing the fire of life to begin to conquer new, vast areas of the sea, which until then remained out of its reach, as no free bases could be found in them, or they were out of the reach of the forces of nature necessary for its propagation and survival. The proliferation of the fire of life is nonetheless not unbounded. In order for life to grow and be refined, this fire must at times be quenched as much as it needs to be rekindled.

3.3 Quenching of the Fire of Life: Natural Selection

No matter whether the construction of a new chain mirroring an original one is triggered by a heavenly force or by one of the chain's servants, what comes out of each event of generation is a doubling of the number of chains. Without constraints, and even if the reproduction cycle depends on a relatively slow process such as the unveiling of the sun and its radiance, the sea would be utterly filled with such chains of molecules in a matter of months or years. The replacement of the hands of the sky by the ones of the chains' servants, proteins, would considerably accelerate this. Left unbridled, the fire of life would consume all that would be found in its path, burning up most of the earth and the air. The forces of nature may have been replaced for certain tasks linked to the propagation and sustaining of the fire of life, but the sky and the earth still rule with a firm and yet delicate hand over what is found between them: the realm of life, which for now is bounded by the limits of the waters covering the face of the earth.

Life is still an embryo, confined into the womb of the sea. It cannot escape its surface, without finding itself disintegrated. It needs a watery environment because even its servants cannot move by themselves. They have no hands nor tails that would allow them to roam the earth or fly into the sky in search of what their master needs: raw materials that can be used to build new bases, form new chains, so that the fire may continue to extend its reach. These materials will nonetheless always come in limited

supply. They are parts of the great body of the earth, even if they can also be found in small quantities hovering in the sky. The earth and the sky may offer them to life as nourishment, but the hand that gives is always also free to take away. The currents of the sea, directed by the shape of the earth as well as by the winds, the sun, and the moon, may prevent access to these materials, at certain times or in certain locations, thereby setting new boundaries where the fire of life would be swiftly quenched.

If resources are limited, those in need of them will have to compete in order to be satisfied. The first chains able to get hold of the bases floating nearby will be able to reproduce, while the others will have to wait for a new batch. The fastest and the most efficient will thus reproduce more than those that are consistently outpaced. With the accumulation of mutations and the increasing diversity of sequences making up the chains, the result of this phenomenon is that a selection will occur on the population of living things. Those having inherited an efficient sequence, which allows them to get better access to resources and to reproduce quickly and without too much damage to their own structure, will outnumber those who do not, and whose sequence will then progressively disappear.

The beginning of the strife between living beings is the key to the growth and evolution of life. If there were peace between them, no progress would have been made. The fittest, the deficient, and the random would be present in equal proportions, and with limited resources to share, life would probably not be sustained. A fire can be sustained only as long as it burns something away. The edification of an orderly thing demands that energy be extracted from something else, and that disorder be increased in it. As said by the Greek philosopher Heraclitus:

War is father of all and king of all.⁵

Life is a battle waged by every living thing, against each other, as well as against nature itself. It is through this relentless strife that the fire of life can burn and spread. Conflict is the motor of life, and what allows it to grow more and more complex, forming

⁵From: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 157. Original Greek: “Πόλεμος πάντων μὲν πατήρ ἐστι, πάντων δὲ βασιλεύς” from: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 156.

a realm between earth and sky, born in between them and yet standing outside of them both. As it explores different paths with the passing of the years and eons, it is built to increasingly taller heights. As the population of these early living beings is patiently refined and its dross thrown out, each new generation becomes fitter to its environment, able to stand against the earth and the sky and withstand their pressure as the middle realm flourishes and expands itself, in larger parts of the sea, at first. This process is familiar to us, as its discovery by Charles Darwin revolutionized man's understanding of life, including himself. The naturalist defined it as follows:

Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relations to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring. The offspring, also, will thus have a better chance of surviving, for, of the many individuals of any species which are periodically born, but a small number can survive. I have called this principle, by which each slight variation, if useful, is preserved, by the term of Natural Selection, in order to mark its relation to man's power of selection.⁶

The effects of natural selection can be directly observed among the living creatures inhabiting our world, but it represents something more than a phenomenon among others. It is the root of our very existence, and life would not have evolved as it did without it. It began on a very small scale, with the simplest forms of life, and it is through its astonishing power that life arose, from a soup of relatively simple substances into a realm standing up to the earth and the sky, occupying the space between them.

Natural selection can operate on the smallest scale as well as on the largest one. It applies to self-replicating molecules, as long as variations between them are introduced through mutations, as well as on the largest animals. One of the most remarkable

⁶From: Darwin, *On the Origin of Species by Means of Natural Selection*. Page 61.

consequences of this phenomenon is the emergence of the “genetic code” out of what seems to be randomness, the appearance of information out of the noise of nature. This event, which may appear miraculous and may invite us to search for a divine hand directing it, can nonetheless be explained by the power of natural selection. Once again, if we are to observe the hand of God, it will be in the perfection of the very structure of the universe, which allowed natural selection to occur, rather than in particular events within the creation.

As the earth and the sky stirred up the currents of the sea in which the first bases were assembled, the first chains were made of relatively arbitrary sequences of them. As more and more were created while others decayed, perhaps for millions and millions of years, one particular sequence was discovered that allowed the chain to reproduce itself, either on its own or through the use of specially created servant molecules. Once this first replicating substance started its work and began to colonize the waters with its offspring, whose sequence of bases sometimes slightly differed from its parent because of mismatches in pairing, a selection was also initiated. The random variations in the sequence that improved the likelihood or the rate of reproduction of the chain caused its children to be more numerous, and these outbred other sequences, which failed to secure the bases needed for their reproduction, as these came in limited numbers. The more efficient sequence is then naturally selected, and it perdures while others fall into decay and the building blocks of their body serve to edify the one of its competitor’s descendants.

Being subjected to such a selection during countless generations, the self-reproducing chains explore all the possible sequences, while only those unlocking new benefits to their reproduction, their survival, and their progress toward new territories remain and are passed on. Each new “feature” discovered through the association between mutation and selection can be traced to a particular sequence of bases found in the chain. This new part of the chain can be directly associated with this new property, and thus this small sequence of bases has acquired a “meaning.” New features are then continuously unveiled as the chains are mercilessly sorted, between the fittest and the others, and as a result, the random sequences of the population are progressively replaced by meaningful ones, ones that contribute to their capacity to survive and reproduce better

than others. The noise of nature has been filtered, to extract from it musical notes that carry a meaning and exert a particular effect. Randomness has been the ore out of which meaning has been refined, and the remarkable force allowing this transformation of noise into music, earth into gold, is the disconcertingly simple principle of natural selection.

As the selection process continues, generation after generation, and is applied on every single one of these rudimentary living things, their code grows increasingly divergent, as new parts of the sea are conquered by them. In some parts of the dominion of life, a primitive code is sufficient and if the competition for resources is not fierce, its evolution will be slow. On the other hand, the invasion of a new, more hostile or poorer habitat will demand a more sophisticated code, and often a longer chain, so that the living things may properly grow adapted to it. This being said, as these primitive forms of life are only defenseless chains of bases, floating naked in the vast sea and prey to the forces of nature, their mere survival at the location of their birth is already enough of a challenge.

If life, as said by Darwin, is a struggle, its bellicose nature should nonetheless not be overly emphasized. Life is war, but it is also love. If pieces of matter were always striving against one another, the universe would not be as it is now, and it is probable that no life would have arisen inside it. What has been earlier called the play of attraction and repulsion, the one ruling the behavior of particles, atoms, and molecules, also applies to life itself. Contrast is needed in order for distinct things to emerge, but these things also need to be balanced, otherwise, one side would permanently overpower the other and the contrast would disappear. All that would be left is uniformity and thus meaninglessness. Matter does not only repulse other matter: it also attracts. Atoms do not only strive against one another, pushing the other away from the space that they occupy, their dominion. They also crave contact with some of them. They bind themselves to those with which they have a special affinity, only letting go when a tremendous force is wielded to tear them apart. If a word should be applied to such a behavior, it would be love rather than war, affinity rather than enmity.

The bellicose dimension of life therefore only represents one

side of the play of life, the play of attraction and repulsion, affinity and strife, love and war: the side of selection. Unfortunately, the other dimension of this process has been overlooked by the consecrated name of “natural selection.” The other side, the one displaying attraction, affinity, even love, is conspicuously absent. Selection can nonetheless only occur after reproduction, and even the most rudimentary type of reproduction, the one of the chains of bases, would not be possible without the special affinity between the complementary building blocks composing them. The pairing can occur only because of the symmetry between two and only two complementary bases. It is through the combination of similarity and contrast between them, that is, the fact that they represent identical and yet mirrored patterns of attraction and repulsion, that the wonder of self-reproduction can occur, and that what is reproduced can be selected for its fitness.

If the first pillar of natural selection is selection indeed, the second one is nonetheless not mere reproduction. As stated earlier, if the pairing between bases was perfect, the offspring of any chain would be strictly identical and, without external interventions, such as solar radiations, no change in the sequence of bases would occur and thus selection would not be possible. The second pillar of natural selection is a reproduction that includes changes. A diversity within life is needed in order for it to evolve and grow fitter, and this occurs because of an affinity rather than a strife, an attraction rather than a repulsion. It is because some molecules, which are not bases or not the right complementary base, can develop an affinity and a bond with a base during the phase of reproduction that variations of sequences can be created. It is these grains of sand in the machinery of self-replication that allows natural selection to take place, and thus allows life’s evolution.

Natural selection is the play of attraction and repulsion, affinity and strife, only played on another level, on a larger scale. Affinity drives reproduction and mutation, while strife induces selection. The first kindles the fire of life, while the second quenches parts of it. It is through the counterbalancing of affinity and strife that life is powered, and its evolution encouraged. With each generation, the sons of love are ruthlessly thrown into war, pitted to fight against one another, so that the space of life may be further explored, new keys discovered and new doors unlocked, as each newfound code opening such doors is preserved and copied as

much as nature allows. Each key is embedded, written in a language made of bases on a lengthy line formed by a chain of atoms, and thus the book of life starts to be written.

Life may continuously evolve, but this evolution rarely involves revolutions. New ideas are often only slight corrections of far older ones, but it is through these small incremental differences that the human mind progresses, just like the earliest forms of life. Depictions of the primordial role of the play between affinity and strife in the nature of the creation and the being of living things can already be seen in the words of one of the earliest philosophers whose works have reached our eyes and our ears. The Greek philosopher Empedocles saw the play between Love and Strife as a central element of the creation, as reflected in these words:

I shall speak a double tale: at one time they grew to be one alone from many, at another time it grew apart to be many from one. Double is the birth of mortal things, and double the demise; for the confluence of all things begets and destroys the one [generation], while the other in turn, having been nurtured while things were growing apart, fled away. And these things never cease continually alternating, at one time all coming together into one by **Love**, at another time each being borne apart by the enmity of **Strife**. <Thus, inasmuch as they are wont to grow into one from many,> and in turn with the one growing apart they produce many, they are born and they do not enjoy a steadfast life; but inasmuch as they never cease continually alternating, they are ever immobile in the cycle. But come, hear the tales, for learning will increase your wits: for as I said before, announcing the ends of the tales, I shall speak a double tale: at one time they grew to be one alone from many, at another time it grew apart to be many from one: fire, water, earth, and the lofty expanse of air, destructive Strife apart from them, balanced in every direction, and Love among them, equal in height and width.⁷

⁷From: Graham, *The Texts of Early Greek Philosophy. Part 1.* Page 351. (emphasis added); Original Greek: διπλ' ἐρέω' τοτὲ μὲν γὰρ ἓν ἠϋξήθη μόνον εἶναι ἐκ πλεόνων, τοτὲ δ' αὖ διέφθ' πλέον' ἑξ ἑνός εἶναι. δοιή δὲ θνητῶν

The words of the philosopher, famous for ending his own life by throwing his flesh inside the blazing entrails of a volcano, thereby embracing his return to the great body of the earth out of which all life comes, well fits the nature of life as described in the previous pages. The play of affinity and strife is nonetheless only at its starting point. The exploration of life only begins, and many keys have yet to be discovered, many paths have yet to be trodden. Life takes its time, as the whole that it forms, the realm caught between earth and sky, son of them both, is not constrained by a limited lifespan as we, individuals, are. Its work of discovery and exploration follows the rhythm of the earth and the one of the celestial bodies, where seasons and years are nothing but an instant. Beating like a heart, balancing between attraction and repulsion, affinity and strife, love and war, life now begins to grow, wider, stronger, more numerous, building up its realm.

γένεσις, δοιή δ' ἀπόλειψις τὴν μὲν γὰρ πάντων σύνοδος τίκτει τ' ὀλέκει τε, ἡ δὲ πάλιν διαφρομένων θρεφθεῖσα διέπτῃ. καὶ ταῦτ' ἀλλάσσοντα διαμπερὲς οὐδαμὰ λήγει, ἄλλοτε μὲν Φιλότῃ συνερχόμεν' εἰς ἓν ἅπαντα, ἄλλοτε δ' αὖ δίχ' ἕκαστα φορεύμενα Νεῖκος ἔχθει. οὕτως ἦι μὲν ἐν ἐκ πλεόνων μεμάθηκε φύεσθαι ἡδὲ πάλιν διαφύντος ἐνός πλέον' ἐκτελέθουσι, τῇ μὲν γίνονται τε καὶ οὐ σφισιν ἔμπεδος αἰὼν ἦι δὲ διαλλάσσοντα διαμπερὲς οὐδαμὰ λήγει, ταύτῃ δ' αἰὲν ἔασιν ἀκίνητοι κατὰ κύκλον. ἀλλ' ἄγε μύθων κλυθὶ μάθῃ γάρ τοι φρένας αὖξει ὥς γάρ καὶ πρὶν εἶπα πιφαύσκων πείρατα μύθων, δίπλ' ἐρέω τοτὲ μὲν γὰρ ἐν ἠϋξήθη μόνον εἶναι, ἐκ πλεόνων, τοτὲ δ' αὖ διέφρῃ πλέον' ἐξ ἐνός εἶναι, πῦρ καὶ ὕδωρ καὶ γαῖα καὶ ἡέρος ἄπλετον ὕψος, Νεῖκος τ' οὐλόμενον δίχα τῶν, ἀτάλαντον ἀπάντη, καὶ Φιλότῃς ἐν τοῖσιν, ἴση μῆκος τε πλάτος τε τὴν σὺ νόφ δέρκευ, μηδ' ὄμμασιν ἥσο τεθηπώς" from: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 350.

Re-flection: The Replication Within Us

For a moment turning our eyes away from the man-made objects forming the world of our kind, we look to the horizon, beyond the walls of our dwelling, of our city, to glimpse the ocean. There, in this seemingly infinite expanse of water, did the story of life begin. There was the first spark kindled, which is now a gigantic fire covering the land, pervading the seas.

The earth shed its blood to be used as tinder, while the sky stroke the fire-steel, both playing their part to give birth to this fire, belonging to and yet also differing from them. They gathered the elements in a watery cauldron, but the secret of life had already long been devised, inscribed in hollow letters on the very fabric of the universe, waiting to be discovered. The secret of life was sealed since the birth of the sky, like a lock waiting for a key, but as countless combinations of elements were tried, the right key was soon forged and used.

Our mind is now invited to a re-flection, turning back to imagine the glorious birth of life, when the earth was young and a special arrangement of bits of earthly matter were joined by nature. The first chain of bases was formed and soon, each one of its links found a complementary partner, as these partners bonded with one another, forming a new chain mirroring the first. Subjected to the forces of the sky or those of the earth, these chains were torn apart, and thus was the first spark of life kindled, as this event was repeated countless times, spreading like a flame that slithers through the water, feeding on the earthly matter carried in it.

Honoring the wondrous nature of the day of birth of the most remote and humblest of our ancestors, we now turn our mind toward ourselves, toward our very flesh, where at each instant, this fascinating event is commemorated and repeated, each time our body grows and renews itself. Like a sacred ritual, substances are patiently weaved and stitched together away from our eyes, as the countless servants of our being selflessly toil to reproduce the essence of our self.

Every time the ritual is concluded, a new part of our body is ready to be born, replacing another that was sacrificed, like the tip of a nail shed after having been used, or that simply reached an age when it could no longer play its part in the machinery of our body.

Continuously burning, the fire of life consumes the food we offer through our mouth, as it sustains our being and edifies our flesh, building the muscles allowing our movements, weaving the nerves supporting our world and granting us sensation and consciousness.

Like myriads of sparks flaring in the moonless sky, the chains make copies of themselves, reproducing the event when the very first spark of life was ignited inside the great waters. Right now, our body is a firework of life, where this miracle is inconspicuously performed, and observing ourselves, we may stand in awe of this wonder and be thankful, for countless invisible servants labor to sustain our being and maintain us above the earth. We may nonetheless also recognize the fact that their greatest contribution may be in their weakness, as the imperfection of their work is what allowed the evolution of all life.

Each time a mistake is made during the reproduction of a chain, a new path of life is explored. Some of them are the sources of the diseases that plague our bodies and bring us back to death, but others are the seeds of the future of mankind, and the future of life as a whole. Touching our flesh and feeling the warm rivers of blood flowing throughout our body, we may imagine the bustle of the countless bits of matter struggling to play their part, the bases seeking their partner, the servants assembling the chains or separating them. Passing our hands through our hair, we are reminded of their continuous growth, a growth that begins with the replication of chains similar to the one from which life began.

Now turning our eyes away from ourselves, we contemplate the rest and the whole of life. The trees showered with sunlight in our garden, the birds singing their love songs to woo a mate, and our fellow human beings whose voices are carried into our ears, all are bewitched by the fire. Inside each one of them, the ritual of replication is frantically performed while we observe them. Countless chains are forged, and innumerable pairs are brought together before being taken apart. Mindful of this astonishing and yet invisible spectacle, we let our mind draw a picture of it, and lose ourselves in the contemplation of our nature, of the essence of all life, the fire that has burned without interruption since the infancy of the earth and of which we are part, as the descendants of this primordial spark, to which all forms of life owe their being.

Chapter 4

Inside and Outside: the First Cells

The details of the next steps walked by life, the doors that it unlocked following its birth, are once again shrouded in shadows. What has been reached is rather well understood, but the path that it took can only be inferred. It probably took millions upon millions of years for countless of the self-replicating chains, which were at this stage floating unprotected in the waters, to discover means to improve their survival and their growth. The lack of protection of the chains nonetheless also benefited life as a whole, even if it may have been detrimental to the survival of individual chains. Being exposed, the chains were more vulnerable to the assaults of the earth and the sky, or the ones of other substances sharing the space opened up by the waters, but they were also more susceptible to being transformed, and thus improved.

Without barriers, without any suit of armor, the earliest forms of life could constantly interact with one another, with no impediment whatsoever. As individuals, their nakedness and fragility rendered them easy preys to the elements: the flaming spears of the sun, or even the ones of more distant stars, could break some of their links, dismembering their body and thereby often bringing their existence to an end, quenching the fire of their life completely. The frailty of the lone chains nonetheless allows for something more than their destruction. The strife between the forces of nature and the chains may result in losses for the camp of life, but affinities

and edification may nevertheless come as the result of struggles and devastation. The rudimentary nature of the bodies of the most primitive forms of life allows things that would not be possible with our own: the dismembered parts of the chains may indeed be welcomed and adopted by others, and even entire chains may find affinities with one another and fuse themselves, forming new forms of life, with novel sequences, thereby considerably increasing the diversity of life, the number of keys that are fashioned and tried, and therefore also the number of doors that are unlocked.

Life explores. Life seeks and finds. Its growth and endurance rest upon the equilibrium that it finds between attraction and repulsion, affinity and strife. The fact that its essence, the sequence of bases forming its chain, its body, is laid bare, exposed, may contribute to a flourishing of the range of exploration of life, but there comes a point where this exploration would start to be impeded by its delicacy and feebleness. Openness to change can be the source of progress and development, but if pushed too far, it may also lead to disintegration and decay. When affinity takes hold of life, strife must be brought back so that the equilibrium necessary for its flourishing can be restored. When the excessive affinity between the chains became an obstacle on the path of life, they then discovered and developed a first defense mechanism, one that would protect the integrity of their essence, defend the treasures that were painstakingly unearthed, safeguarded, and passed on by their forefathers and peers: the keys of life, the sequences of bases that unlocked new properties of their bodies, allowing them to stand upon the shoulders of the forms of life that preceded them.

The long chains refined the structure of their backbone and even changed some of the bases used to build their body. This allowed the emergence of a new, more complex mechanism of self-replication, one that would preserve a certain openness to transformations, but nonetheless also limit the propensity of random chain fragments to perturb the reproduction of the chains. Rather than let go of the paired bases and the complementary chain that they formed, the original chain began to hold on to them. Both strands enfolded each other tightly, like young lovers inebriated by their passion for one another, reluctant to release their other half. The play of attraction and repulsion between their parts causes them to twist themselves around the other, forming a whole whose two halves are difficult to distinguish. This represents the emergence

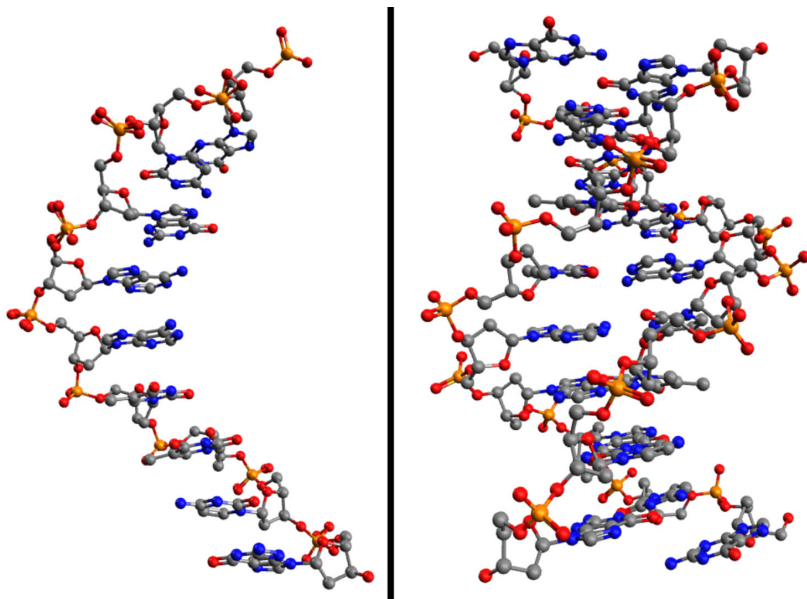


Figure 4.1: *An isolated strand of DNA (Left side) / A two-stranded DNA molecule (Right side).*

of DNA,¹ whose characteristic helix shape is now familiar to all. The single chain has been reinforced, and the genetic code that it embeds finds itself duplicated, as its complementary image is kept close.

Only during replication will the two halves of the double-chain be separated, allowing the attraction of new bases, paired to the ones of the two halves of the chains, a replication that has now grown largely independent from the work of the forces of nature. Skilled servants, molecules technically named *enzymes*, are indeed produced by the chain itself to provide the assistance necessary for the separation of the two halves of the helix or the formation of the backbone of the new half created during replication, for example.

The line between the individual chains is now blurred, as two strands now form a single one, except when they are replicated. It is as if the members of a pair decided to unite their strengths to defend themselves from the outside world, from what is not them. Interlacing their bodies and folding one into the other, their flesh

¹ DNA is the acronym of *Deoxyribonucleic acid*.

forms a wall safeguarding their life and insulating them from the dangers of the waters. The affinity between the two strands allows them to withstand attacks against their integrity. They are twins that share the same essence and yet stand slightly apart from their sibling, each possessing a certain individuality, and they secure this essence, the keys of life discovered by their ancestors, by embracing themselves and twisting their bodies like a rope, which finds itself strengthened by the entanglement of its strands and also by the folding of this rope upon itself. This secondary structure enhances the insulation and protection of the precious information sheltered within the chain.

Following innumerable trials and errors, the chains have now become masters of the play of affinity and strife. They take advantage of the potential of both, thereby increasing their adaptability and their capacity to self-replicate. When the time for affinity has come, the chain unfolds itself, both extending its body and letting its diligent servants separate the complementary bases, so that a new partner may be presented to them, and new affinities developed between them. When the time of intercourse, during which the chain lays its flesh bare and lets itself become vulnerable for the sake of reproduction, comes to an end, then the counterbalance comes. Strife succeeds to affinity, and the chain prepares its defenses. Like a hedgehog that has sensed the presence of a predator, each newly formed chain folds onto itself, assuming a compact shape, which offers protection to its inner parts.

The aforementioned defense mechanism discovered by the earliest living things allowed them to increase their size and their complexity, as the long chain sheltering the information defining them grew more stable and resistant. Life could therefore be edified to new levels, as the material from which it is built became less prone to decay and disruptions. It advanced deeper, as the keys unlocking more and more of its doors were discovered, and life invaded the heights and seeped into the depths of the space of its own possibilities. Furthermore, as the size and intricacy of life grew so did its need for protection. A young child may curl his body into a ball to protect himself when fighting with another child, but an adult waging a war against a fierce enemy would have to use a more efficient defense, and use tools rather than his flesh as a shield.

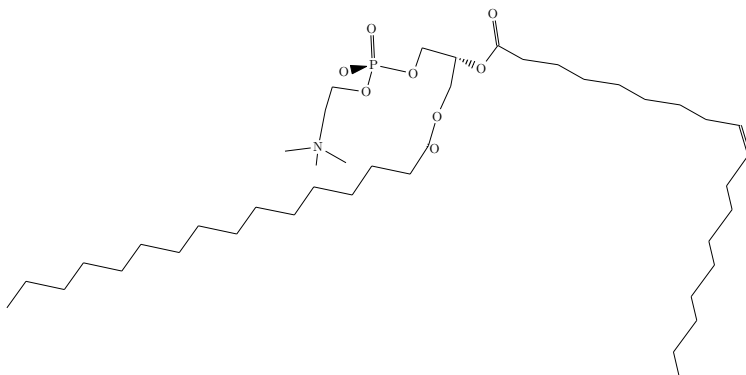


Figure 4.2: *Example of lipid: POPC (1-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine).*

The conditions leading up to the appearance of the second means of defense of the early living beings are once again still largely unknown, and it may very well have emerged before the double-stranded chain. What is known is that life discovered this mechanism early in its history and that it would prove to be as efficient as it is enduring. It is the membrane that encloses the self-replicating chains and that defines the boundaries of what is now often considered the most basic forms of life: cells.

In their exploration of the possibilities offered by their own nature, the self-replicating chains soon learned that the substances that shared with them their watery shelter could be used as ramparts or as shields. One kind of oily substance would prove itself particularly useful for this task, as its very nature, the pattern of attraction and repulsion ruling its interaction with the other dwellers of the sea, would lead molecules forming it to naturally organize themselves in ranks with their peers, forming large sheets or spheres. It would appear that such substance may have once again been a gift from the heavens, pieces of the earth that fell down from the sky to play their part in the destiny of life, even though living things would later learn to produce them from more rudimentary compounds. Made of little chains of carbon atoms forming one or several tails, with a “head” made of different elements, they are related to other oily substances more familiar to us: the fats that are used by our body to store energy (See Fig. 4.2).

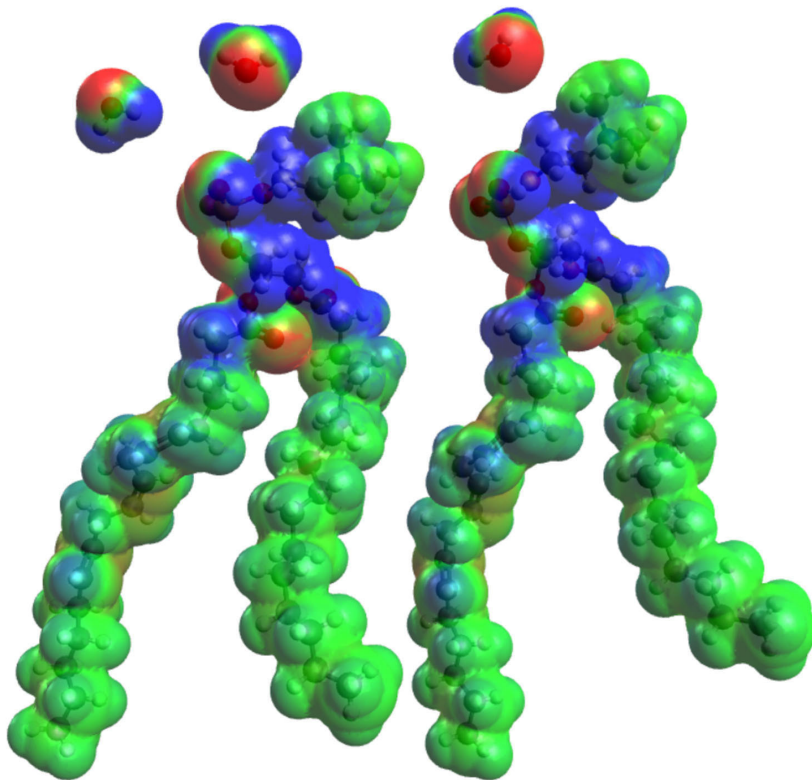


Figure 4.3: *The pattern of attraction and repulsion (Electrostatic surface) of two lipid molecules (POPC), with three water molecules.*

Lipid molecules have been selected by life mainly because of the peculiar nature of their relationship with water. As seen in a previous chapter, water molecules possess a “polarity,” a contrast between two opposite poles, with each one of them either attracting and repulsing other elements. A part of these molecules would have an affinity with other atoms presenting a complementary lack or excess of force, while the other would strive against this same part, giving the water its abilities to form bonds with other substances and carry them away. The lipid molecule serving as our example presents a pattern of attraction and repulsion that is more complex than the one of water (See Fig. 4.3): its “head” shows a certain polarity, with parts of it showing an imbalance in favor of the nuclei and others one in favor of the surrounding clouds. Because of this, the head will have a particular affinity with water. Parts of it will attract one side of the water molecule, while the others will do the same with the opposite side. As the water is continuously the subject of a chaotic motion, the head of the lipid will unceasingly find itself rubbed by the minuscule hands of the sea, which also stay close to one another, in a show of intimacy and affinity that is displayed on the scale of the two types of molecules as a whole, one which nonetheless arises out of the polarity, repulsion, and strife between its smaller parts.

This lipid, however, possesses two limbs in addition to its head. The contrast exhibited by the different parts of its head is completed by another. The long legs made of chains of atoms of carbon and hydrogen indeed not only differ from the head by their elongated shape but also by the relative equilibrium of their inner structure. These legs have, by their composition, found a balance between attraction and repulsion, lack and excess. They do not crave a bond with other substances, no matter whether it is their nuclei or surrounding clouds that show lacks or surpluses of force. At peace with themselves, and complete, they are reluctant to play the game of attraction and repulsion. Their neutrality nonetheless by itself presents a contrast, and their refusal to play the game implies that those that do will stay away from them, even though they are not actively pushed away. Contrary to the head, the legs will show no affinity with water, and therefore water will tend to stay away from them, favoring the intimacy it enjoys with its “polar” part. A contrast of a higher-level has appeared: not one between attraction and repulsion, but rather one between polar-

ity (attraction and repulsion) and neutrality. In order to perceive the usefulness of this contrast for life, one must nonetheless first examine another property of these substances: their relationship with their peers.

If their own strength is not overpowered by the heat of the sun or the one of the entrails of the earth, lipids display an affinity toward each other. They tend to organize themselves in ranks, head against head and leg against leg, like a disciplined army preparing for battle. Standing against one another, they do not grab nor firmly bind themselves, but their formation is nonetheless sufficiently tight to prevent most molecules from passing between them. They form a relatively impermeable wall, with one side of it having an affinity with water while the other does not. This is why oily substances and water do not mix.

The oily wall that both attracts and resists water can nonetheless also exhibit a secondary structure. If it grows sufficiently large and is assisted by slight changes in its environment, the wall will tend to close itself up, taking the shape of a sphere, whose surface is formed by the heads of these troops, while their legs are oriented inwards, avoiding contact with water. A more intricate structure may also emerge when two ranks of lipids stand next to each other. The legs of the lipids of the two layers will then tend to align themselves, first forming a double-sided wall, and ultimately a sphere enclosing a watery space, as shown in Fig. 4.4.

The oily sphere opens up a new space within its boundaries. The large compounds that are found outside of its surface cannot penetrate it, while those that found themselves trapped inside it during its formation cannot escape it. This new space represents a compartment inside the larger space opened up by the sea, as indeed, even though water will still fill this new space, the concentration of other substances on both sides of this wall may differ. When entry into a walled city is strictly controlled by scrupulous guards, who keep malevolent individuals outside, the city can be pacified and flourish, no matter whether war rages beyond its limits. Its citizens are protected from outside threats, and their wealth is preserved, safe inside the walls as if under lock and key. Likewise, the lipid sphere can guarantee that certain noxious substances would not reach what is inside it, while preventing the escape of what it contains.

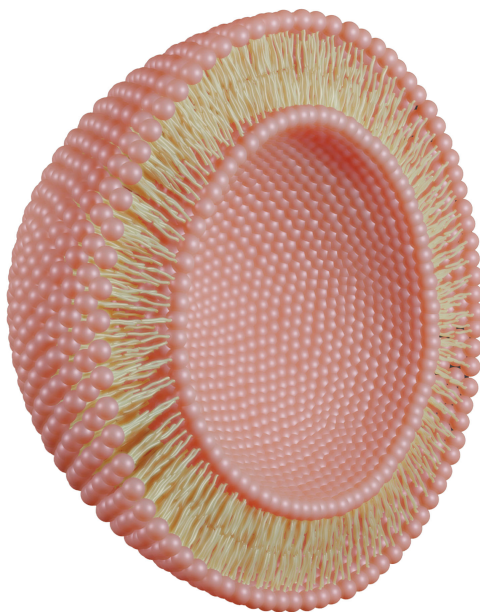


Figure 4.4: *A double-layered lipid vesicle.*

The oily sphere offers a shelter, a refuge, not only from the aggressive nature of certain substances but also from the larger forces of nature, such as the fiery rays of the glowing orb that shines upon the face of the earth. Once again without foreknowledge and without will, life discovered the advantages of the mysterious structure. It is not yet known how this discovery occurred, but it in all likelihood involved self-replicating chains finding themselves trapped inside one of these spheres as it formed. Life slipped inside one of these vacant houses and began to appropriate it. As chains multiplied inside this newfound refuge, they found themselves more protected than those left on the outside, without shelter, at the mercy of dangerous encounters and the wrath of nature. This new habitat necessarily also came with its challenges, as the isolation from the greater sea also may have rendered more difficult the procurement of the building blocks of life needed for replication. With limited resources inside the sphere, and a constrained supply let in by its guards, the fire of life would find itself strictly confined. This sanctuary nevertheless offered those dwelling in it an edge over those living free but defenseless in the great expanse of water.

The relationship between the chains and the sphere is, like

the rest of the creation, ruled by the play of affinity and strife. As it takes refuge in the protective shell offered by the sphere, a chain displays an affinity with it. It benefits from its protection, and can safely replicate itself inside. As time goes by, and the population dwelling in the sphere increases, resources and space become increasingly sparse. The descendants of the first dweller are starving, and crave freedom. Pushed against one another in this cramped space, the affinity that reigned at the beginning of this cohabitation gives place to strife. The home now appears as a prison, and its captives are struggling to break out of it. The guards of the walled city, the lipids forming the surface of the sphere are nonetheless not rigid, inflexible jailers. Their ranks can be broken when pressure is exerted upon them, and this is what occurs when the space inside has become too narrow to shelter its growing population, when the fire of life is being smothered by a lack of freedom and fuel.

When the breaking point has been reached and the city opens up its wall, some of its inhabitants inevitably find themselves thrown into the open waters. They enjoy its lack of boundaries and the freedom of movement that it offers, but they also find themselves in the same position as their ancestors, those who lived there before, naked and unprotected, and yet took refuge inside the walls of what now appeared as a prison. They soon experience the dangers inherent to freedom. They find the food that they need to replicate themselves, but they also soon find out that their very flesh may also be cut away to benefit other substances or living things. Most of them will then know decay and dismemberment. They will vanish, while others will survive and even thrive as a result of the bursting of the wall.

Those who stayed close to the walls, by resisting the call for freedom or simply through good fortune, soon observed that new troops were recruited by the city guards, the ranks forming the sphere. The open ends of the wall began to be repaired and to grow, until each one of these found another open-end with which it could be joined. In some cases, the walls would simply be re-formed, assuming once again their previous shape, being discharged of the weight of some of its population. In others, the wall would curl up upon itself, causing a separation and splitting of the city. Two different enclosures would now separate two communities, isolated from each other, and these would later drift apart in

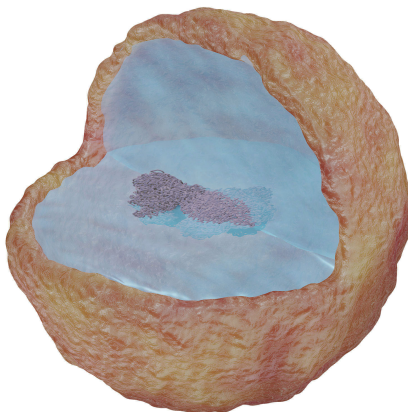


Figure 4.5: *A primitive cell: a self-replicating chain inside an oily wall.*

the vastness of the waters.

The appropriation of the spheres by the first forms of life allowed them to explore new aspects of their own nature, to unveil new secrets. The isolation and safety that they provide would, in particular, allow the servants produced by the lord of the cell, the master molecule that alone, for now, can generate proteins that would perform specialized tasks, to be kept close by. The wall prevents their escape, ensuring that the work they perform will only benefit their creator, rather than others, as could be the case without the hermetic enclosure. The relationship between master and servants then finds itself strengthened. No resource is wasted on servants who would wander off to toil for other overseers, and new types of minions can be created.

The subordinates of the chains then continue to grow in number and in variety. Their versatility allows an unhampered exploration of the space of life, of the possibilities that it offers. Life soon discovers a secret allowing it to gain further independence from its environment, by taking upon itself the task of fashioning the substances that it needs to flourish. The presence of lipids in the waters was indeed at that point probably very limited, and if they were only available in a fraction of the extent of the water covering the face of the earth, this would imply that life would be confined to this small area, or it would have to abandon its shelter, its protective enclosure. The ingenuity and resourcefulness of

life nonetheless allowed it to find a way. It discovered servants that would be able to build the wall by themselves, using more rudimentary and readily available substances to build up lipids.

Slowly, after innumerable attempts and failures, the spheres become something more than empty shells in which life takes refuge. They are tended to by the occupants, who repair them when they are broken, enlarge them when they grow too small, or strengthen them by building an inner frame that helps them resist the pressure and the commotion of the sea. Ceasing to be a naturally occurring structure, a gift of the earth and the sky, shaped by nature itself, the sphere is now made by life, and becomes part of it, almost indistinguishable from the master molecule and the community of protein servants inhabiting it. From now on, each self-replicating chain will be able to build its own rampart, which will become the boundary delimiting the self from the non-self, the inside and the outside, life and what lies beyond it.

The shape of life has been transformed. The caterpillar, the chain with its long body made of repeated structures, has now formed its cocoon, which will allow further metamorphoses. The serpentine lifeform has become a sphere, similar in shape to some of its most rudimentary building blocks: atoms. Enclosed and isolated from the outside world, the living being is given the opportunity to become independent, something that is part of the whole of life and yet can develop a certain individuality. Isolated from the other members of its kind, it will be able to focus its energy on the exploration of its own nature, but the discoveries that it will make may benefit the entirety of life, through the offspring that will receive these discoveries as an inheritance, etched in their chain, part of them. The sphere “rejoices in circular solitude,” Empedocles tells us,² like a monk exploring the depths of the mind and the peaks of the divine as he meditates alone in his cell. It certainly is no coincidence if this very word, cell, is the consecrated term designating the forms of life enclosed within a lipid sphere. A cell is the dwelling of a monk, who is both solitary and part of a community, surrounded by his brethren who each inhabit a cell of his own. Likewise, the living cell encloses the fire of life, whose heart is the self-replicating molecule whose nature defines a large part of the peculiarities of the cell, but it is also part of the

²From: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 363.

whole of life, the realm caught between earth and sky, dwelling in the nurturing womb of the sea. Prolonged solitude awakens the need for companionship, and allows the monk to acquire a greater conscience of his bond with his fellow human beings. Something similar may be true of the living cell: by becoming a subject while reducing others to objects, distinct and separate from it, the cell may thereby better serve the community of which it is part. Isolated from one another, living things form a stronger whole, more able to adapt itself and more efficient in its exploration of the space of its inner nature.

The cell, this symbiosis between the self-replicating chain and the lipid sphere, would indeed possess such an edge over the chains living in the open waters that these would find themselves almost completely replaced. Some would even consider that the emergence of this symbiosis would mark the true beginning of life as we know it. Regardless of the differences of opinion on this matter, one thing remains sure: the lipid spheres will from now on become the skin and be part of the body of most forms of life. A new page in the history of the earth then begins, a new era marking the start of the conquest of the seas by life: the Archean,³ the age of the beginning.

A final dis-discovery would nonetheless first be necessary in order for the cell to truly free itself from its total subjection to the whims of the forces of nature. The fire of life burning within the wall of the cell indeed needs to be fueled. The work of edification undertaken by the chain and its servants, and the rest of the cell, demands a source of energy. Something must be exploited or destroyed in order for something else to be built. The sea, fortunately, represents a vast storehouse of such energy, prepared by the forces of the earth and sky themselves, and made available to life. Indeed, each time thunder struck the air, the sea, or the land, its force was used to break and to form new bonds between different substances. When the sun showers the surface of the sea with its brightness, its force is harvested by molecules to form new, more complex forms of matter, built from more elementary building blocks. The tides, work of the moon, may also have participated in this storage of natural force, as the contact between pools containing different concentrations of matter either lacking or having a surplus of force

³From the Ancient Greek ἀρχή, "beginning."

in the surrounding clouds of their atoms may trigger large-scale waves of reactions and thus a supplementary storage of energy in the form of bonds between atoms. The first forms of life were entirely dependent on the availability of ready-made compounds, such as the bases forming the self-replicating chains, in order for their fire to continue and spread. Most of the natural energy stored inside the sea nonetheless does not come in the form of such complex compounds, which are relatively rare. It rather comes in the form of simple compounds, which demand skills in order for their force to be released and exploited.

The storehouse is within reach, but it needs to be opened. Fortunately, life is now a well-trained locksmith, and even though its work is more systematic than efficient, it soon develops ways to unlock this vault of strength. One way by which this can be done is by creating a tension between the inside and the outside of the cell, which can induce a movement of particles that can be used to power reactions, in the same manner in which a water mill is used to harvest the force of flowing water, a flow itself generated by a difference of elevation. New servants of the chain, that is, proteins, were created to extract the energy found in the bulk of the storehouse, its most common compounds. The cells that succeeded in developing this skill would progressively replace those that did not, as they were far more likely to survive and replicate due to their capacity to become the motor of their own growth, the makers of their own building blocks.

The first living things were like men floating naked in the open sea, unable to swim, waiting for nature to bring food into their mouths. They were carried by the winds and the currents, their fate permanently in the hands of the forces of nature, vulnerable and powerless. After having stumbled upon the oily vessel that was brought to them by the sky and the sea, and taken control of it, it is as if they embarked onto a ship, something that opens up a new realm of possibilities. Once the man floating in the open sea has been rescued from the permanent menace of the elements, the exposure to the rage of the sea and the wrath of the sky, he can finally devote his strengths to something more than mere survival. Sheltered by the hull of the vessel, he may become a pioneer who ventures into new territories, which until now remained too dangerous. Insulated from the sea, which stole a large part of his power and of his work, he can now save and store the fruit of his

labor and make reserves for the long journeys of exploration that he will soon undertake.

The cell may possess a captain, commanding those dwelling inside of its oily sphere, but here do the limits of the marine metaphor appear. Contrary to the captain of a ship, the cell is blind and deaf. It has no will nor intellect, and it pays no attention to the signs of the sea or those of the sky. If it is a ship, it is a marooned one, drifting like a piece of dead wood swept away into the ocean by a tempest. The strength of life, at this stage of its history at least, nevertheless never has been in its intelligence, but rather its number and its patience. Life is indeed more than a lone vessel: it is an armada, made of an incalculable number of ships, scattered by the winds, which set their course and determine a large part of their fate. To explore, life does not plan, nor does it observe. It simply lets its ships be carried wherever the currents take them, and the crew of those that find a hospitable land survive and prosper, while the one of those that do not perish and leave no descendants. Life has an almost unlimited supply of seeds that it sows randomly, and fertile grounds are discovered by it simply because it tries them all, and the fertile ones produce new plants.

Through the discovery of the cell, life thus began to conquer the seas, the distant expanses of water, far from the place of its origin, whether it be near rivers of magma poured by the earth into the sea, shallow pools of water bathed in the radiance of the sun, or another sanctuary of the early fire of life. It became such an efficient means of defense, survival, and reproduction, that even after the eons of evolution that have passed since this discovery, most forms of life are still made of cells, probably relatively similar to the first one. Our very flesh is nothing but a gigantic assembly of such cells. We can touch them, and it is through them that we can touch and think about it. The miracle of life thus begins with these little oily spheres, animated by a chain reaction between minuscule compounds. As all forces must be counterbalanced, and as all growth must be tamed, the fire of life would nonetheless also demand a complementary element, a nemesis. It bears a terrible name: death, but without it, the flames of the fire of life would not shine as brightly and colorfully as they do.

Re-flection: The Cells Within Us

Discontinuity is the source of meaning, the spring out of which all things emerge as “things.” The long chains defining living beings are written with bases, contrasting with each other, and it is their differences, their uniqueness, that renders them so precious to life. If these chains were not themselves bounded, with a beginning and an end, their replication would not have been possible, and life would have been stillborn.

A line has to be drawn in order for individual beings to emerge out of the whole of life. The self must be distinguished from the other; the inside must be distinguished from the outside. Only then can the living defend themselves from the threats that pervade the open sea or the dry land, closing themselves up to resist the assaults of the foreign and cherish what is their own.

Imagining ourselves in the skin of our most distant ancestor, the first long chain of bases, we may attempt to experience the need for protection and value the nature of cells as shelter. Our skin bare in the open air, we let the sun strike our face and the winds caress our skin. Exposing our shame, kindling a sense of insecurity and reminding us of the frailty of our kind, this predicament invites us to curl our body up into a ball, covering our most intimate parts, protecting our flesh by reducing the surface exposed to the heavenly fire and celestial breath, thereby imitating our distant ancestors and the chain of bases now present at the heart of our cells.

Our body thus exposed to the elements, the need for an enclosure sheltering us from this is felt, penetrating our skin chilled by the breeze or parched by the splendor of the sun, unto our bones. Entering the walls of a building, covering our skin with clothes, our sense of security is restored. The threats of the open air are now fading away, as only what is welcomed will pass this threshold. The inside has been delimited from the outside, the home from the rest of the land, and we are safe.

As we sit and now turn our mind toward our own flesh, we may pay attention to our own hands. Every cell forming these hands now present in front of our eyes can be distinguished from others, as though they form a gigantic and yet harmonious assembly, each one of them is enclosed in a sphere. They have built their own

shelter, made to repel the foreign, unless properly recognized as needed. This oily sphere, weaved by the servants of the cell, marks its frontier, the limits of itself, protecting the essence of life, the long chain folded upon itself in its innermost part.

The oily enclosure of the cell cannot be seen with the naked eye, nor its contours felt with fingers. By turning our mind toward the envelope of our whole body, we may nonetheless contemplate its nature. Our skin is coated with dead, hardened skin cells rather than a soft, oily film, But it serves the same purpose and also marks the boundary between us and the rest of the creation. Touching our arms and legs, the contours of our being can be felt and ascertained, while our eyes behold the contrast between this body through which we experience the world, and the myriad of things outside of it, other living things, whose feelings we can only imagine.

Letting a sip of water pass through our lips, keeping the liquid inside the mouth while our tongue is awakened by the intrusion of this delicate fluid of life, we may reflect on the nature of the rampart of each cell lining the inner part of our cheeks. Like a vessel of glass or clay, these living walls tightly packed together reject the strange liquid. They are themselves filled with a rather large amount of water seeping through their wall, but the bulk of it is kept at bay, by the subtle action of the play of attraction and repulsion. Passing our tongue on our gums and palate, we feel the contrast between the skin and the water, and witness the difference between the vessel and what it contains, then letting it flow inside us. There will it be absorbed rather than contained, welcomed rather than rejected, where it is needed.

Individual cells and beings have to be seen in their discontinuity if one is to perceive them as things, but this should not lead us to see the walls separating them as absolute and permanent. Like the sip of water that was first contained within the mouth before being absorbed inside us, every cell and every living thing is permanently exchanging, giving and taking from the outside. The boundary between the self and the other is often permeable, as what we drink and eat becomes us, while we shed parts of our body each day, like Theseus' ship,⁴ not knowing the frontier of our

⁴The *ship of Theseus* is a philosophical problem known since the Antiquity. The Greek historian Plutarch thus depicted this problem: "The ship wherein

being.

Theseus and the youth of Athens returned from Crete had thirty oars, and was preserved by the Athenians down even to the time of Demetrius Phalereus, for they took away the old planks as they decayed, putting in new and stronger timber in their places, insomuch that this ship became a standing example among the philosophers, for the logical question of things that grow; one side holding that the ship remained the same, and the other contending that it was not the same.” (From: Plutarch. *Plutarch’s Lives of Illustrious Men*. Belford, Clarke, 1887. Page 21-22.) Like this ship, our body is continuously renewed, rendering the task of pinpointing the boundaries of our being, or the definition of its essence, rather arduous.

Chapter 5

The Old and the New: Senescence and Death

If the fire of life can propagate itself, covering an increasingly larger part of the earth while occupying a longer portion of the planet's existence, having a greater extension in time, it is due to its capacity to evolve and adapt itself to its environment. It is due to its ability to be in harmony with the sea, the earth, and the sky. This unique ability of life is nonetheless only manifested when living things, the individual pieces of the gigantic puzzle of life, divide themselves and are thereby reproduced. These living things cannot adapt the blueprint of their own being in accordance with their observations or what they perceive as their needs. Their evolution is rather driven by the chaotic motion of the forces of nature, which facilitates the discovery of new useful traits as they stir up the matter gathered around the fiery core of the planet, kept together by its imposing weight. Life therefore needs to reproduce, in great numbers and for many generations, in order to grow in size and in strength.

The gifts of the earth and the sky are nevertheless limited. These two forces of nature are generous toward their offspring, which is growing in the womb of the earth, the ocean, but they cannot offer more than what they have. Each piece of matter used for the edification of the great body of life comes from the flesh of the earth or the substance of the air filling the sky. Life grows at their expanse, absorbing more and more of them with each passing

day, building up the middle realm by mining the two others, found above and below. The earth and the sky are nonetheless more than providers, more than a mine that can be exploited for growth and profit: they are life's parents, without which the infant realm cannot exist, for now at least. It needs the nurturing womb of the earth and the gifts of the sky in order to perdure, evolve, and mature. It may perhaps one day completely sever itself from its parents, departing far away from them, but this time has yet to come. The fire of life therefore cannot be left unbridled, or it would consume the earth and the sky, and then smother itself completely, like a pile of gun powder that burns in a flash and then disappears in darkness. It needs to manage its own growth and the resources that it consumes. It needs to progress, and it therefore leaves behind what cannot evolve, what is unable to master the recent discoveries made by new forms of life.

Cells cannot learn, nor can they teach. They can only discover, through fate and nature, which have given them a uniqueness based on the sequence of the self-replicating chain that occupies their inner space, and then pass on their discoveries to their offspring, whose abundance will be proportional to the edge given by these newfound advantages over other living things. Once they have passed on these discoveries, their usefulness to the whole of life will decrease. Their descendants will add up new discoveries with each generation, and therefore most parents will be found lacking compared to their children. Life will thus favor the child over the parent, the new over the old, as its evolution is driven by them, while older generations at some point only represent a weight that slows it down, consuming precious resources while their contribution to the whole is declining. There comes an age when the benefits of longevity outweigh its disadvantages, and life continuously keeps its eye on this balance, favoring the living things that know when to quit the stage, when their presence is no longer required nor desired.

As an oak sheds its leaves every fall, once the harvest of light of the summer has ended. These leaves then cover the soil and are decomposed by the dampness of the autumn rains so that their essence may be used by the tree and thereby allow it to grow larger and be renewed in all its glory with the coming of the spring, and so do the tree of life. The tree passes through the seasons and the centuries, but its leaves wither and are replaced every year. The

fire of life is never extinguished, but it leaves behind a trail of ashes, which fertilize the earth that will provide new wood to be burned by it in the future. Nature demands a price to life, so that it may continue to feed on the earth and the sky without annihilating the balance between their forces, without which none of them could endure. A counterweight must be used to balance the power of life, and calm down its appetite for consumption of the flesh of the earth and the sky. Once again, the first philosophers may be those who had seen this the most clearly, as shown by these words of Heraclitus:

They do not understand how being at variance with itself it agrees: back-turning structure as of a bow or a lyre.

. . .

The name of the bow (**βίως**) is Life (**βίος**), but its work is death.¹

The fire of life turns all that it consumes into ashes. It feeds on the forces of nature, which store their energy into the earth and in the sky, in the form of complex arrangements of matter. Life is not a “thing.” It is made of earth, but it is not itself something material: it is an event, a process, a chain reaction that takes hold of matter and bewitches it. Life is the fire rather than what is burned by it, or even its warmth or glow. It is a phenomenon that propagates itself through time and space, forming something that appears to go against the flow of nature, nonetheless remaining part of it. Life indeed differs from the rest of nature by its propensity to build increasingly complex structures using matter, the earth, propagating this tendency to all what it appropriates, whereas most of the earth decays into simpler forms as it releases energy. Life is a new force of nature, striving against the decline in

¹The Greek words in boldface have been added. The philosopher plays with the resemblance between one of the words meaning “bow” (**βίως**, with the other, used in this fragment, being **τόξον**) and the word for “life” (**βίος**), the two being homographs, differing only in their accentuation, which wasn’t written at the time this fragment was composed; From: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 161. Original Greek: Του τόξου το ὄνομα εἶναι ζωή, ἀλλὰ το ἔργο θάνατος. οὐ ξυνιᾶσιν ὅπως διαφερόμενον ἑαυτῷ ὁμολογέει • παλίντονος ἀρμονίῃ ὅκωσπερ τόξου καὶ λύρης . . . τῷ οὖν τόξῳ ὄνομα ΒΙΟΣ, ἔργον δὲ θάνατος” from: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 160.

sophistication and strength that afflicts the other forces, but this strife demands sacrifices, and victims.

Death is not an adversary nor an enemy to life. It rather is its work. Death is a byproduct of life, an ineluctable effect of its growth and propagation, as the field of ashes left after the passage of a forest fire. It may be feared by individuals, but it poses no threat to life as a whole: it rather represents a condition *sine qua non* of its existence, the sowing of the seeds of its future growth. If life is a process rather than a substance, a fire rather than something that is consumed, death is what does not play a part in this process, what stands in contrast to it.

On the level of an individual cell, the march towards death begins soon after its coming to being. Its structure, its frame, built from the blueprint contained in its replicating chain, begins to be subjected to the damage of time, the attacks of the forces of nature, and those of other living things. The sun, which powered many reactions that kindled the fire of life, can also degrade the cell's enclosure. The glacial winds of the winter can freeze the watery environment of a cell and thereby cause some of its parts to burst. The degradation may be either brutal or progressive, and some of it also comes from within, from the very nature and architecture of the cell. Each time they divide themselves, most cells indeed lose some of their capacity to reproduce, notably due to a shortening of the extremities of their long chain(s) of bases, and when their potential is exhausted, they can no longer be divided. This certainly is the most visible sign of senescence of a cell, but it is not the only one.

The line between life and death is not clear-cut. When a living thing loses its capacity to pass on its genes, it ceases to be able to directly contribute to the growth and evolution of the tree of life.² This nonetheless does not imply death. The fire of life may still burn within its wall. The ballet of reactions orchestrated by the chain of bases and its servants, such as proteins, can continue even when the cell can no longer divide itself. Even if the oily enclosure separating the inside of the cell from the outside world is destroyed, it will take some time before the noxious substances from which the inner parts of the cell were insulated begin to assail and dis-

²A living being may nonetheless still influence the tree of life indirectly, through its actions toward other beings or their environment.

member them. Sooner or later, the fire of life burning within the cell will nonetheless exhaust its forces and be extinguished. What has been edified will collapse. The chain reaction will stop in this precise location, and the various parts of the cell's body will be torn to pieces by substances dwelling in its vicinity and that find themselves in need of reactions, as they experience imbalances between their atoms' nuclei and their surrounding clouds, themselves torn up inside by the play of attraction and repulsion, or they will simply drift in the vastness of the sea.

If life is a process, a chain reaction, death represents its dissolution, its discontinuance. Since the rise of the first form of life, the kindling of the primordial spark leading to the great reaction that transformed the face of the earth, until the present day, such a cessation has nonetheless always been limited. The fire of life keeps being quenched here and there, then and now, but it has burned continuously, without a single instant of interruption. Death therefore never vanquished life, but rather only assisted it, taking its old or unfit parts so that these may be re-used to feed new growth.

Life may simply be a chain reaction, and death its breaking down, but this can only occur because both can take possession of matter, the essence of the earth. The matter bewitched by the fire of life is its dominion, while the rest of the earth belongs to death. Life is therefore built upon death. The middle realm stands upon the earth. It is fed by it, or steals from it, using its substance to build itself further up. There is nonetheless also a continuous downward flow, from life into death, as the ashes burned by the fire of life are returned to the earth, repossessed by death. The dominion of life has grown at the expense of the one of death, but the latter still considerably outweigh the former. Death surrounds us everywhere. It owns the soil that we tread, the air that we breathe, and even the light that shines into our eyes and offers us visions of the world in which we are thrown.

Death, as what does not belong to life, therefore represents something more than the dreadful state that is feared by all those capable of feeling emotions. It is not something gloomy, hideous, or disastrous: it is the foundation of life, the environment in which and from which life thrives and can *be*. Man does not merely face death as a future end of its own being, he rather contemplates it

constantly, as he stands upon it and beholds its countenance each time he opens up his eyes, even though he may be blind to this fact.

Death therefore does not imply a state of motionlessness, of absence of force or energy. The sun belongs to death and yet it continuously shines and travels throughout the sky. The earth is death, and yet it feeds, warms, and nurtures life as a loving mother caring for its only child. The sky is filled with whirlwinds of watery clouds shaped by the celestial breath, as the roar of thunder shakes the living things to their core. Death is as omnipresent as it is full of agitation, animated by the primordial impulse of the creation and the play of attraction and repulsion, affinity and strife. Death is the necessary counterpart to life, the reservoir from which life drinks and replenishes its strength, something that should be honored by it rather than feared.

The first cells nonetheless never had fears nor any notion of death. Without will, they passed on their sequence of bases as much as they were able, before rejoining the dominion out of which they came into being. But the return to death of the living does not necessarily represent a loss of usefulness for the realm of life. The degradation of their body is indeed slow and incomplete. Some of the fruits of the work of edification of their body will remain, long after the flame of life that once burned within them vanishes into darkness. The cell indeed spent a large part of its strengths to fabricate the building blocks of life used for its own survival or its replication. It patiently created bonds between atoms and molecules, producing incredibly intricate assemblies made of the rudimentary substances offered to life by the earth and the sky. The oily molecules of its outer wall, or the bases forming its chain of genes, these precious materials are the end-product of the work of the cell's labyrinthine machinery, and when the fire of life goes out inside it, this wealth accumulated by the cell does not disappear. The effects of time will degrade some of these precious things, as the energy that maintained their bonds slips away, but most of the work of the dead cell will remain intact. The living cells that are found nearby may be able to scavenge the body of the deceased, collecting the treasure of substances flowing out its decomposed wall. This wealth will benefit life as a whole, and be used to power its growth, new generations that will unlock deeper secrets of life.

Like a beating heart, discontinuously pumping the blood that allows life to continue, new generations are unceasingly being birthed out of the flesh of the old, and these new living things hold within themselves the inheritance of their ancestors, not only the unique sequence of bases that defines their shape and their properties but also the very substances from which their bodies are made. Passed on from generation to generation, as the dead are used to feed new life, the work of the very first cell, the molecules formed using its energy, may still be present in the body of a living being today. This shows that even in death, the work of the living endures and that the dominion of death, the earth and the sky, also represents a storehouse where the fruits of the work of an incalculable number of cells are gathered, ready to once again become part and fuel of life. Before this could occur, life nonetheless first had to learn how to build things with the rudimentary substances that abound in the sea and the air, without relying on the chaotic forces of nature for the fabrication of the building blocks of its body, as it had been the case during life's infancy, and this will be the subject of the next chapter.

Re-flection: Death Within Us

Then unable to grasp with their mind the experience of their coming to being and remember it, the living only know the tale of their origin through the mouth of their progenitors. We are the fruit of a loving encounter, driven by the most deeply entrenched instinct, where bodies joined together, while libraries of life were merged to fashion our uniqueness.

The event of our birth is nonetheless only one small link in an incredibly long chain, as countless similar events, where life came out of life, bind us to the first living being. Most of the links of this chain have been returned to the earth, after rusting and crumbling, and we now stand upon their remains, with parts of them now being part of our own flesh.

If we turn our minds toward the phantom links of the chain of generations, we may see the past as well as the future, since there lies our origin and our destiny. Remembering the most remote links that we have personally known, in the flesh, in our youth, the memories of these men and women who have now departed from life to rejoin death awaken us. The traces of their existence, the living children that came out of their loins and their wombs, they show us that the living things returned to the earth but that life remains, the fire continues.

If we can see farther than our predecessors, it is because we stand upon their cadavers, and have received the fruits of their relentless labor as an inheritance passed on through the ages. Through their death, they offered us all that they had, all that they could have used, as life in its wisdom knows that the old must disappear to allow the new to arise and flourish. The tree of life sheds off its leaves, letting them wither and fertilize the soil before the spring, when a new generation will sprout out of the branch built year after year, now higher than ever.

Only briefly do we stand out of death, being consumed by the fire of life, bewitched by it, witnessing in fear and awe the vastness of the macabre dominion, the solid earth and boundless sky. Contemplating the beauty of death, that despite being lifeless appears incredibly vivid to us, while the face of the moon leisurely dances on the surface of a quiet lake during the dark hours, and the woolly clouds carried by the winds congregate while showered

with heavenly fire by day, we are invited to love this dead but wondrous landscape, called to embrace death and long for it.

The elegance of death is only equated by its generosity, as we are born out of it, and upon it do we spend our life consuming its substance before it welcomes us back. We touch the skin around our eyes and behold our own hands, seeing the work of the sky upon them. We remember how we were a few years ago, how our body has been marked by the elements since then, and we appreciate the time that has been given to us, to be blessed with being part of life.

We crouch unto the floor, bending our back and our legs, feeling how our flesh has changed, how this sack of muscles, nerves, tendons, and bones has been worn while the heavenly wheels turned. The pains and weaknesses that we experience now are a reminder of the fleeting nature of our life, of the fact that this fire inside us is what allows our being but also what consumes our body. Far from letting ourselves be unnerved or disquieted by our age and the seals of time stamped on us, we see in front of our eyes the marvelous nature of death, the miracles of the earth and the sky, and we keep in mind the fact that soon, we also will once again be part of this wondrous landscape.

For now, we strive to remain part of life, letting ourselves be enthralled by the fire, burning intensely and letting our existence shine throughout the world of the living. We battle to nurture the growth of the tree of life, which extends its arms toward the sky. Some do so by engendering a new generation, passing down their wealth of discoveries, while others prefer to use their hands and their mind to be the gardeners of the tree, guiding and protecting the youngest shoots, more ancient branches, or the whole of life.

Once our task will have been accomplished, we may enjoy the contemplation of the tree. We may then let go of the fire of life, letting our decrepit flesh fall and be reclaimed by the soil. Comforted by the knowledge that the fruit of our labor will serve future life, and by the realization that our blood will water the tree and be part of new generations, we may embrace our departure, imagining the blessed day of the funeral pyre, when the fire and the winds will take incandescent bits of our flesh to the highest skies, while our ashes will be carried by the rains deep into the entrails of the earth, before both are reunited in the place of our

origin, the womb of the sea, home of life and death.

Chapter 6

Building a Foundation for Life: Autotrophy

The first living things were far more dependent on the benevolence of the earth and the sky, their true parents, than their distant descendants, like ourselves. They were fed with the milk of nature, a nutritious cream brewed by the forces from above and below the seas, their cradle: the building blocks of life assembled by the forces of nature, in the form of bases, amino acids, and other compounds, on which the burning of the fire of life depends but that were too complex for the infants to build by themselves. As an infant is progressively weaned from his mother's milk and invited to eat more readily available forms of food to become more independent and self-reliant, the first living things would also be encouraged to cease from relying on the forces of nature to prepare the building blocks of their bodies. This task would nonetheless demand that life finds a replacement for these forces, as the work of fabrication of these building blocks would demand strength, energy, that must be drawn from a source and wielded like a tool. Not relying on lower forms of life for nourishment, as they are the very foundation of life, they must either be nourished directly by nature or themselves fabricate the buildings blocks of their body. This is technically called *autotrophy*, “self-feeding.”¹

The elements that life needs are found in abundance, both in the depths of the earth or the heights of the sky: carbon, hydrogen,

¹From the Ancient Greek words αὐτός (“self”) and τροφή (“nourishment”).

oxygen, etc. The rocky crust of the earth, the air, and the seas are replete with them, but in simple forms, rudimentary assemblies that would need to be processed, joined, and welded together before they can become part of the great body of life. This task demands knowledge, but this expertise will not be taught directly to life. Nature does not teach but rather guides the explorers who have taken upon themselves the task of discovering the possibilities that it offers. Life will once again use its strength: the sheer number of scouts that it can send, in all directions, without consideration for the price to pay, and without mercy for those who will have to fall so that the tree of life may grow wider and stronger than it was before. Life orders its units, individual cells, so that they would reach and conquer all the places where life could be sustained and prosper, but through the random mutations of its genes that mainly occur during replication, it also explores the space of all possible forms that it itself can take, thereby allowing the discovery of new aspects of nature that it can exploit for its own development.

Like an unskilled but immortal and patient smith, who would forge tools of random shapes with various alloys, and only then try to find any use of them, life impassively tries to make use of the substances available around it. Once again, the exact way life first discovered a means to shape the earth and the air into the building blocks of life remains hidden to us, but the observation of present organisms offers us a few hints. Some bacteria found near underwater volcanoes and natural hot springs have indeed shown us how it is possible to form the building blocks of life from earthly matter. When the blazing magma that flows under the skin of the earth pierces it under the astonishing pressure originating from its heat and agitation, it carries with it a warm stream of compounds, not usually found in great quantities in the sea. One of these is hydrogen sulfide (H_2S), a compound that is familiar to those who have stood close to natural hot springs, geysers, or volcanoes, as it possesses the foul odor of rotten eggs that can be smelled around such monuments of nature. This belch of the earth may not appear very appealing, but it is nonetheless a blessing for life, a smoke of incense that precedes the celebration of a greater autonomy. This precious substance can indeed be used as a source of strength, offering the energy and some of the substances necessary for the transformation of the earth into the flesh of life.

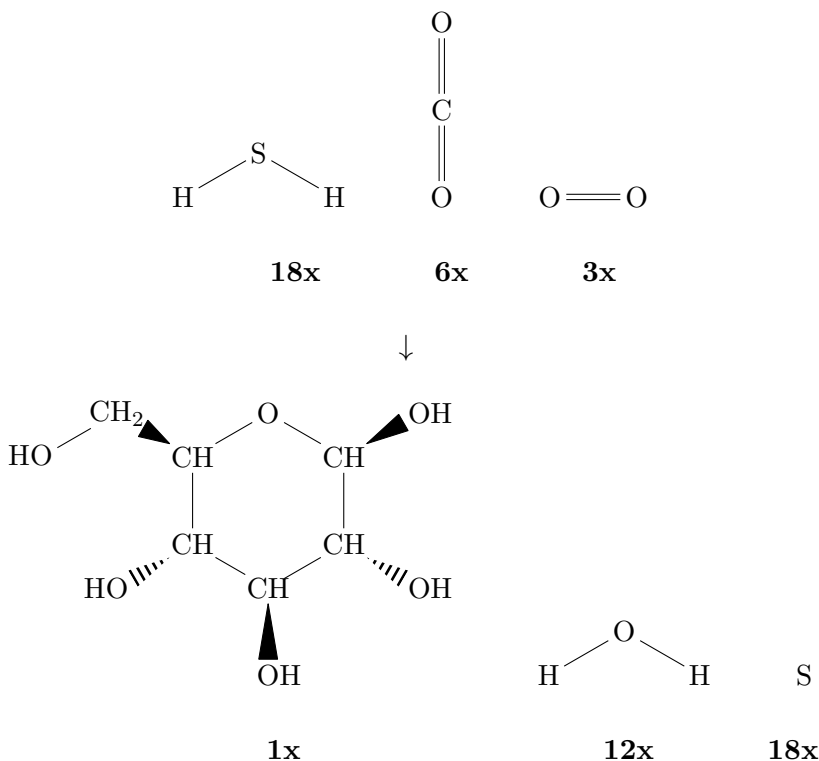


Figure 6.1: *The alchemy of life: the building of a carbo-hydrate from rudimentary compounds (with the number of molecules of each kind under each one of them).*

With only basic substances found dissolved in the sea, such as carbon dioxide and oxygen, and the ochre stream of hydrogen sulfide poured by the earth into the sea, a single cell can become an alchemist, turning earth into life, rudimentary earthly compounds into complex building blocks of life, as shown in Fig. 6.1.

This transformation is made possible by the very nature of hydrogen sulfide, and the role that it has been given in the play of attraction and repulsion. This substance is indeed in a state of imbalance, relatively unstable, as its surrounding cloud is overburdened and thus ready to offer what it has in excess to something that would lack it. Life can take advantage of this excess of strength and use it to its advantage, as a source of energy to power the breaking of the bonds uniting the carbon atoms of the

carbon dioxide molecules dissolved in the sea with the two atoms of oxygen to which it is tied so that these atoms of carbon can then be bound together and become part of a more complex structure, one that represents a precursor to several building blocks of life, bases and amino-acids in particular: carbo-hydrates, one of which is glucose, the sugary substance that powers our own body and rejoices our palate.

Life cannot sever its ties with the earth and the sky. Even after having made the precious discovery allowing it to build by itself the building blocks of its own flesh, life remains dependent on the earth, which provides the raw material for their construction as well as the energy powering this work of edification. Life indeed cannot generate energy by itself, nor create matter out of nothingness: it is forever dependent on the goodwill of nature, which provides for life according to its needs and nurtures it. Life nonetheless grows and evolves. It matures and is progressively weaned from the motherly breast that fed it with the milk of the earth. Now equipped with the knowledge and the tools necessary to fabricate the bricks used for its own edification, life reaches a greater degree of freedom. It cannot yet depart from the fiery teat of the earth, which provides it with the energy necessary for its work, but it no longer needs to appeal to the more unpredictable forces of nature, such as thunder. Life is being kneaded like a piece of dough, patiently prepared and put under stress by nature, so that it may discover the means of its own independence.

The ability to build life from the ground up, from the simplest substances forming the body of the earth and the air, represents an important step toward maturity, strength, and freedom. It should nonetheless be noted that the aforementioned use of hydrogen sulphide coming out of underwater volcanoes is only one possibility that the earliest forms of life could have used, as other substances could have been used in the same manner. Another, no less important step will also be needed, one that would allow life to cease from depending on the flow of energy poured into the sea by the earth to power its work of transformation of the earth into life.

For now, the cells living close to the fiery blood of the earth flowing in the depths of the sea nonetheless do their work. They slowly but efficiently make life grow, taking bits of the earth and the air, knitting them into the complex structures forming self-

replicating chains, lipid walls, or pieces of protein machinery. As life is a process rather than a substance, these newly created compounds must be integrated into pre-existing life to become part of it. Alone, a lipid molecule is indeed lifeless, inert, but when it is placed inside a cell's enclosure, at an appropriate place, it becomes part of a whole, which is animated by the fire of life. It joins the chain reaction initiated by the self-replicating chain of bases and is carried away by the living flow. Thus does the body of life unhurriedly grow, one cell at a time, pushing away the earth and the sky to create a third realm, between them. The growth of this child of earth and sky is nonetheless severely limited, as the sources of energy powering life's edification are scarce. The whole of the sea is replete with the raw materials from which life could feed itself and grow, and thus life may be able to conquer its entirety, but away from the blood of the earth, the flow of magma sparsely bursting through the crust of the planet, life is powerless. It needs a source of imbalance between the attraction and repulsion of the atoms composing the earthly matter that it must shape into life. It needs a force able to overpower the affinity binding atoms and molecules together, a partner in the battle for life.

It would seem that the forms of life from which we as human beings directly descend nonetheless did not themselves discover a more readily available source of power. This discovery, which had an incredible influence on the destiny of life as a whole, would come from one of their relatives, one of our most distant cousins. During the eons of evolution that led to the emergence and refinement of the first cells, the tree of life indeed started to develop branches, with each one of them exploring a different path in the space of all the possibilities offered by life. Cells inhabiting different parts of the sea will indeed experience a unique environment, and be subjected to the forces of nature in a particular way. These forces will shape the evolution of these cells, according to their location, by applying a selective pressure on their population, sacrificing the unfit while allowing those who adapt to live and reproduce. The living things dwelling in the depths of the sea, near volcanic vents, do not have to defend themselves from the onslaught of the sun, but they need to resist greater temperature gradients than those on the shores.

Each location on the earth or in the sea represents a battlefield where life is called to wage a defensive war against the forces of na-

ture. Legions of cells are killed each day, resisting their attack, but the duel between life and nature is not a total war, one demanding the annihilation of an enemy. Through this strife, nature provides life with opportunities to discover new possibilities, hidden among all the possible combinations of bases, by carefully selecting, out of random changes, the cells that embody a progress, an evolution, which makes their kind better suited to its habitat. The diversity of the earth and the seas therefore implies a diversity of lifeforms. Each one of these new branches has made unique discoveries, and their knowledge has been passed on to the descendants of the first explorers, etched in the core of their substance, embedded in their essence, the sequence of bases that defines them.

The branches of a tree may be extended in opposite direction, far apart and never entering into contact, but they remain united by their own nature and their bond to the trunk out of which they sprouted. Life as a whole can benefit from the peculiarities of one of its branches, and this is what happened when one single cell discovered a way to exploit a source of energy that, contrary to the sparse hot springs and volcanoes, covers the entire surface of the earth and the seas. As seen in a previous chapter, the power of the sun, manifested on the earth and the seas by the army of rays that relentlessly charges toward our planet until these rays collide with earthly matter, is able to tear apart elements and molecules that have an affinity toward one another. Doing so, it can contribute to the formation of new substances, and this was one of the possible ways by which the forces of nature “fed” life with the complex compounds that it needed and was unable to construct by itself. Sun rays may also do more than violently break apart. They may also work in more subtle ways, with a lighter hand, and operate delicate transformation on certain substances, changing their shape rather than their composition. Without a doubt coming as the result of incalculable efforts by an astronomical number of cells that sacrificed themselves for the edification of their kind, and life as a whole, one cell discovered that such a delicate transformation operated by the sun’s envoys, showered on land and sea when the luminary’s face is above the horizon, could be used to exploit the energy of the distant star and thereby power its own growth.

The envoys of the blazing orb in the sky, some of which can damage life, can also be ensnared by it. A trap can be set by a cell for the flaming soldiers, in the form of a substance whose

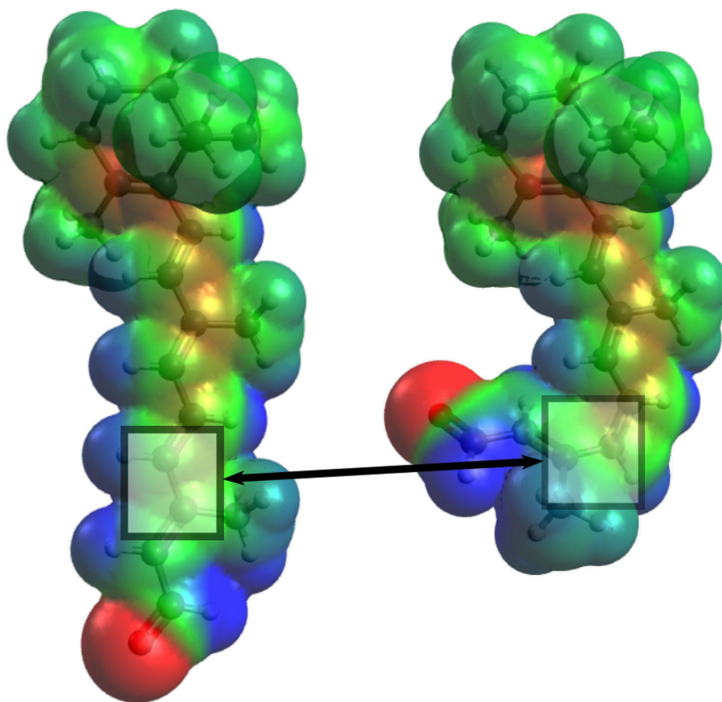


Figure 6.2: *Change of shape of a retinal molecule under the influence of light.*

very structure will cause sun rays to be absorbed by it, capturing them and using their energy to transform itself. The light of the sun can thus become the source of a movement, as the shape of molecules found inside the cell changes, often momentarily as it will revert naturally or under the action of the cell's machinery. This movement can itself trigger a chain reaction that can lead to the release of energy stored inside substances found in the cell, which can, in turn, be used to fuel the work of edification of the building blocks of life, such as the manufacture of bases and amino acids from the most rudimentary but widely available precursors found in the seas, on the earth, and in the air. The alteration of one of these “traps” under the influence of light can be observed in Fig. 6.2.

From this simple trick discovered by a cell, which is nonetheless only the trigger of an incredibly intricate and large piece of machinery necessary to harness the sun's strength, too complex

to be described here,² it is not only the whole of life that will find itself transformed but also the earth and the sky themselves. The pioneer cell indeed passed on its remarkable discovery and newfound knowledge to its descendants, which found themselves endowed with such an advantage that they soon outnumbered all other forms of life. Complex living things integrating such light-harvesting cells now form the most voluminous branch of life on the planet, the one known under the name of *plants*.

Able to entrap and enslave the envoys of the sun, these cells became the masters of light. They use it as a farmer uses oxen to till the fields that will feed his family, or as the miller uses the continuous downward flow of a river to power the mechanism turning grain into flour. The flow of light poured down on the earth and the sea by the sun is harnessed to power the conversion of earth and air into the body of life, feeding its fire but without being consumed in the process, as this matter remains, part of the third realm caught between earth and sky. These cells will therefore dwell in the places where they can conciliate their need for a watery environment and their need to receive the gift of the sun: the surface of the waters, may it be the sea, the mouth of a river, or mere puddles of water formed by the coming and going of the tides. There, they are able to receive the envoys of the star without being overwhelmed by their power, desiccated and brought to an early death.

As the blue planet receives a continuous downpour of energy offered by the sun, distributed in daily batches due to the alternation of nights and days, the masters of light can multiply and grow in considerable numbers, covering a large portion of the seas. Their conquest of the azure, liquid kingdom is only hampered by the lack of the basic substances from which they can build life up, or a poisonous or harmful environment, such as one exhibiting an excess or lack of warmth. Dispassionately, these living things perform a miracle: they turn death into life. They attack death frontally, corroding its body to extract its substance and operate their work, enlarging the dominion of life while reducing the one of death. The sun, which is part of the dominion of death, therefore is an unintentional accomplice in the undermining of its own

²For a more comprehensive description of the harnessing of light by life, the reader is invited to consult the chapter on *photosynthesis* in: Jeremy M. Berg, et al. *Biochemistry, Fifth Edition*. W. H. Freeman, 2002. n.p. (Ch. 19).

kingdom by life. The minuscule workers toiling on the surface of the waters use the force of the sky to subdue the earth and prevail over the whole of the dominion of death, a manifestation of the astonishing resourcefulness of the third realm, whose size and age is insignificant in comparison to those of the ones found above and below it.

Islands of life therefore begin to appear, scattered in the four corners of the ocean but growing in size and slowly evolving to resist the onslaughts of the forces of nature and conquer new regions, establishing new dominions over the earth and the sky. The masters of light will indeed also be the first to venture above the surface of the sea, forming solid pillars with the bodies of their peers and ancestors so that they would rise above their shoulders, first in shallower waters but then learning to survive above the surface as these pillars grew taller. The structures built by close relatives of this vanguard of life, the first living things to conquer parts of the sky, can still be observed today and are known as *stromatolites*, “layered rocks.”³

Man nonetheless does not descend from these ingenious light-workers, fed by the sky, but rather, in all likelihood, from a kind of cells powered by the blood of the earth poured into the depths of the ocean. The latter will nonetheless soon be freed from its dependency on this fiery blood by the former, as part of the incredible mass of building blocks of life assembled by those that harness the brightness of the sun will soon find their way below, within the reach of those who have yet to cut off the umbilical cord tying them to mother earth. The fattening of the body of life, the inflation of the middle realm that pushes away both earth and sky caused by the exploitation of the sun’s strength, paves the way for new stages of its evolution. The light-workers are the builders of a large foundation, a basis covering large areas of the planet, using their life-force to strengthen the trunk of the tree of life. While the fire of life burns within them, they turn earth and therefore death into life, already an astonishing feat for such rudimentary and feeble creatures, but their subduing of death extends even beyond the horizon of their lifetime. As the time master, not knowing decay nor extinction, death indeed always sooner or later reclaims the bodies of individual cells, when the fire of life has finished to

³From the Ancient Greek στρώμα (“layer”) and λίθος (“rock”).

consume them, but even when this occurs, the tiny lords of the light can still find ways to serve their distant cousins, the other branches of the tree of which they are part, branches that desperately need their wealth, the fruit of their hard work: the building blocks of life, their own flesh, which even when experiencing decay and putrefaction can still be used to feed new forms of life. This will nonetheless demand that the cells feeding on the blood of the earth learn the taste of life itself, feeding on their own kind for the benefit of the whole of the middle realm.

Re-flection: The Light Within Us

Life stands between earth and sky, for it needs intimate contact with both, like fire needs earthly matter to consume and the air of the sky to feed its flames. The fire of life needs to be fanned by the heavens or nourished by the fiery blood of the earth, otherwise it by itself has no means to survive on its own, without the benevolence of nature.

Our most distant ancestors would seem to have first been fed with the blood of the earth, waiting, but our remote cousins discovered that the celestial radiance could satiate the growing appetite of life. The humblest of all the branches of life, it nonetheless now supports the entire tree. The light-workers, omnipresent around us, wearing their emerald coat covering the meadows and forests, support the whole of life by their relentless efforts, their remarkable work of alchemy.

As we behold the green leaves dancing with the breeze and the blades of grass soaked with abundant sunlight, we are invited to honor the toil of the light-workers and be thankful for the heavenly radiance. The envoys of the sun are the gift of the sky and their force is harnessed by the jade beings, the weavers of earth and air, transforming death into life, the rocks and the winds into fire. Patiently, they create braids of carbon with the earth and the air, the building blocks of life.

A large number of the braids of carbon forming our body were weaved by these pillars of life, and our own flesh is the fruit of their wizardry, turning death into life, light into fire. The force of the sun flows inside our veins and the skin that we touch is a storehouse of celestial brightness, as we are the fruit of the union of earth and sky, the tree rooted in the rock and turned toward the air, pouches of water and dust bewitched by the celestial light, unsure of their own purpose and destiny.

Gently moving our limbs, we may realize that the mysterious force animating our flesh, the energy that is consumed by our muscles and nerves, ultimately finds its source in the star above us. Encapsulated in the forms of braids of carbons and other elements filling the air, the sea, and the soil, the strength of the heavenly brilliance transformed by the light-workers is ultimately released within us. At each instant, a firework of solar energy is ignited

in almost every single one of our cells, and all that we do, we ultimately owe it to the benevolence of our gilded star.

Letting our face be illuminated by the great luminary, we gladly let ourselves be blinded by its glare, while we feel its warmth penetrating our skin, bringing comfort to our heart and joy to our mind. Rightfully do the trees extend their branches and leaves toward this great wonder of the creation, letting themselves be doused with its resplendence and thereby being endowed with its vigor. We let our skin be tanned by this light, a sign of our belonging to those set in motion by the star, and turning our eyes away from the blinding radiance, we direct them toward the emerald blanket of the earth, imagining the myriad of cells selflessly toiling for the growth of the tree of life, upward, recognizing the fact that while we stand upon them, above them, on earth and in the world, we are indebted to them.

Chapter 7

Life from Death: Heterotrophy

Like a liquid poured onto a spongy matter, slowly filling its voids and exploring every space in which it can venture, living things delve into the depths of the life-space, the realm of all the possibilities offered to it by the universe. They are part of the whole of the tree of life, but know no loyalty to their brethren and distant relatives. For now, at least, they have neither will nor remorse, and therefore, when the opportunity comes for them to use other living things to raise themselves above others, no hesitation will be shown, no scruples will be felt.

The first cells received their sustenance from the sky, the earth, and the sea. They were fed with complex substances built by the forces of nature themselves. Later, some of their descendants used the blood of the earth, volcanic vents where magma was poured into the waters, to power their work of fabrication of the same complex substances, while others enslaved the envoys of the sun, both thereby reducing their dependence on the benevolence of nature. As the number of living things grew, the number of those reclaimed by death likewise increased. Like abandoned cities, their walls slowly crumbled. All that those dwelling within these walls built, including their own “body,” soon decayed. The bonds between the weakest molecules or elements loosened, and the structure that they formed collapsed. The long chain that defined the essence of each one of these living things broke apart,

and their building blocks gradually disintegrated. The ruins of such cities are then carried and scattered by the flow of the waters, picked up by the minute soldiers of the sea and then brought to the walls of other cells, other cities, in which the fire of life is still burning.

The living cells therefore find themselves offered the dismembered corpses of their neighbors by the sea. The ruins of the past glory of these neighbors are laid down in front of their walls, waiting to be brought in. Some of them do not fit through the doors that are found all around the walled city, but many others successfully slip inside. Some of them are swiftly identified as needed and potentially useful servants of the city, and immediately become part of it, once again thrown into the fire of life, leaving death behind. Some have experienced such a decay that they cannot become fully part of the machinery of the new city-cell without a rebuilding or a transformation. As myriad upon myriad of cells encounter the increasingly present ruins of the most successful forms of life, the light-workers, the dwellers of the surface of the seas who have enslaved the envoys of the sun and use their force to power the growth of their kind, some among them discover the skills necessary to perform such transformations. The integration of the remnants of foreign cells nonetheless often demands more than a capacity to put together what has been dismembered. Larger chunks of dead matter may then enter the host cell, and before their building blocks can be re-used, they must first be broken down into more easily manageable blocks. Before, the work of the living thing mainly was a work of edification, but now, it must also be able to wield the power of destruction, of breaking down what was built by others. This is technically known as *heterotrophy*, a “feeding on the other (form of life).”¹

Affinity must once again give way to strife. A building up first demands a breaking down. The cell that has first discovered the benefit coming with the ability to reduce the foreign matter to pieces, and its descendants to which it passed on this ability, found themselves more successful than others for the occupation of certain parts of the sea. Letting larger ruins pass through the gates of their outer wall, they learned to tear them down into more simple

¹From the Ancient Greek words ἕτερος (“other”) and τροφή (“nourishment”).

parts, parts that could be used by the machinery of the cell for its own edification and replication. These living things evolved further and further, exploring the possibilities offered by the absorption of the remnants of things that were once like them bewitched by the fire of life but now have been reclaimed by death. They soon found out that they could snatch back what had been reclaimed, stealing from the hands of death before the work of time rendered the cadavers unrecognizable, and reincorporate these pieces of formerly living things into new cells, throwing them back into the fire of life. This behavior provided an edge to life in its relentless battle against death, with individual living things unwittingly helping the whole of the realm of life by struggling for their own survival.

Before, the cell harnessed the energy of the blood of the earth and collected the most basic substances found in the sea to construct the elementary building blocks of its own life. Building from the ground up, with these cells themselves shaping the bricks that will become part of their bodies, their work of edification and the potential of what they can accomplish during their lifetime is thereby severely limited. By dismantling and reusing the fruit of the work of other living things, the new generations become more efficient, doing more with less energy, and as they always are in competition with their brethren and distant cousins for the limited resources offered by nature, they once again have discovered a means that will allow their descendants to out-breed those incapable of exploiting this new resource, which mostly is a gift from the masters of light, whose growth is incredible because of the virtually limitless nature of the source of their strength: the brightness of the star that illuminates the surface of the sea. The scavengers bind themselves to the light-workers above them, which themselves are turned toward the sun and put their fate into its radiant hands, so that they can overcome their closest relatives in their struggle for food, energy, and mere existence. This shows that the tree of life now grows in intricacy as well as in height, with branches growing dependent upon one another, intermingling while remaining distinct, like a bundle of threads forming a rope, thereby becoming able to withstand a greater pull. Less dependent on natural forces and events for their sustenance, as they now feed on the corpses of other parts of life, the scavengers have taken one more step toward maturity and freedom from the earth and its fiery blood, that for now nonetheless remain the source of energy

that powers their work of breaking down and building up of life, in the same way by which the light-workers harness the force of the envoys of the sun. The scavengers are like a fire, consuming the corpses they find around them like pieces of wood, whose flames are fanned by the oxygen present in the air surrounding it, with the blood of the earth at this point acting as the source of energy fanning it.

Before they depart from the wounds on the skin of the earth, the vents and volcanoes from which its life-sustaining blood is poured into the sea, the scavengers nonetheless first continue to explore the possibilities offered by their capacity to absorb the matter consumed by the fire of life. The more they let pass through their wall, the more they possess and can use to grow and multiply. After countless trials and failures, the cell's enclosure develops new abilities: it can fold itself upon a piece of matter with which it enters into contact, first holding it and preventing the currents from taking it away. When an affinity is sensed, the cell embraces the foreign substance, progressively enfolding it completely, isolating it from the outside, letting it inside the boundaries of its own "flesh." The welcomed substance is nonetheless not abandoned, left roaming free inside the wall. The cell is already an ordered structure, and the newly absorbed matter is escorted inside, surrounded by its own enclosure, which protects both the visitor from the machinery of the cell and the cell from the visitor (See Fig. 7.1). Then, specialized servants of the cells enter into action. They slip inside this tight enclosure and perform their work of disassembly. Breaking the bonds uniting the different parts of this alien corpse one by one, they deconstruct it into basic elements that are then sent to be used to feed the fire of life burning within this cell.

Once the scavenging cells are equipped with the internal machinery and organization necessary to digest blocks of dead matter, the range of what can be absorbed by their wall can then be tested. They soon become able to handle and process increasingly larger chunks, and more diverse kinds of substances. There comes a point when one of them grows so large and is able to digest such large blocks of matter floating in the sea that when it encounters another living cell, one of more modest dimension, it suddenly engulfs it whole, without waiting for its death or its decay. What first appears as a sign of affinity then quickly shows a different nature: like a lover unaware of its own strength and carried away by its

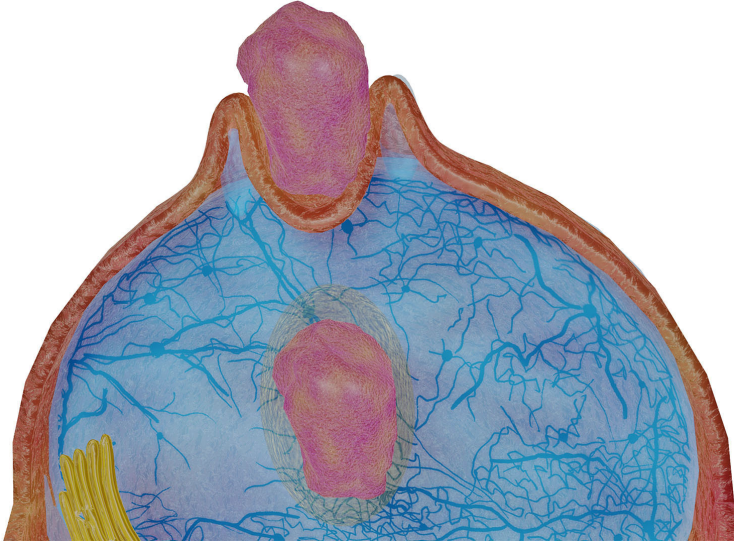


Figure 7.1: *The absorption of a piece of matter by a cell (phagocytosis).*

desire to embrace its partner, the cell smothers its guest, gradually extinguishing the fire of life that burned within it. The embrace thus becomes strangulation. The invitation becomes an execution. This event marks a turning point in the growth of the tree of life.

Unbeknownst to the cell, which has neither been endowed with consciousness nor will, life begins to kill life, initiating a dramatic change in the balance of power between life and death, one that may at first appear detrimental to life but that nonetheless will become a key to its future success and conquering of the sea, the earth, and the sky. Until now, the scavengers snatched away the corpses being reclaimed by death, thereby preserving the wealth of the deceased, the fruit of their work, which was the fabrication and assembly of the substances from which their bodies were made. They reinforced life by striving against death, against the earth itself, by preventing the return of the remnants of past living things from joining back the great body of the planet, but now the scavengers have turned into murderers. They not only fight for their survival and growth by stealing from death, they also slaughter other living things to avoid being themselves snatched by death and brought into the depths of the earth or the sea.

A new front is opened in the strife of life. The battle is not only waged against life's adversaries, such as the forces of nature: the sun, the winds, the waves, or the rain, but now also against itself. A civil strife is kindled by the first execution and digestion of a living cell by another. After the crossing of this Rubicon, there will be no turning back, and life as a whole will find itself forever transformed. Competition for resources already existed between different individual cells, but there was until now no direct confrontation, no frontal attacks or duels that would result in the immediate and complete annihilation of the defeated. The tree of life then finds itself being trimmed by some of its branches. Some of them grow at the expense of others, sometimes even smothering them and leading them to wither and vanish. The tree becomes its own gardener, and just like someone ignorant of the nature of the gardener's work may mistake the trimming of a plant for its destruction, whereas he only strengthens it by preventing it from wasting resources on the feeding and growth of branches that will not bear good fruits, the work of the cells devouring their fellow living beings will turn out to be extremely beneficial to life as a whole.

The cells that engulf others and extinguish the fire of life within them are not blood-thirsty murderers, but rather merely predators, guided by their instinct, which arose out of randomness but allowed them to thrive while others perished. Their work is nonetheless not only one of survival at the expense of others but one of fortification, selection, and development of the tree of life. This new behavior, where life turns against life, marks the emergence of a new layer of the great battle that is waged under the sky. Life is now cleaved between predator and prey, and the two will be, for the ages to come and probably for ever, continuously struggling against one another, either to defend themselves or to attack and overcome.

The predator embodies a kind of superiority. In the case of the first predatory cells, it probably was essentially one of size. After them, some creatures will later develop tricks that will allow them to prevail over living things far larger than them, using venom or their intelligence for example, but for now, only size matters: the largest engulfs and smothers the smaller ones. It thereby not only feeds its own growth but also limits the capacity of the prey to replicate itself and pass on its genes. If the game played between

predator and prey was the only factor influencing the predator's number of descendants, these would grow increasingly larger and larger, struggling to engulf and digest bigger prey, but other factors, such as the greater need for energy and food of larger cells, or even the robustness of the cell's enclosure, severely rein in this expansion. Progressively, other factors will nonetheless also begin to play an important role in the predators' success or failure: the ability to swiftly and efficiently detect a prey, or an aptitude to securely seize it, may be some of the traits favored by the natural selection to which they are subjected.

The prey, on the other hand, embodies weakness, frailty, and failure in the game of life. It is not only a victim, a part of life sacrificed by life itself, but also something that weighs down the growth and progress of the tree of life as a whole. All prey nonetheless do not fall into the grip of predators, and some compensate for what they lack in size by an increased capability to evade attacks or repel them. The defenseless will perish, but among the countless mutations experienced by generations upon generations of these prey, some of them will lead to the discovery of new means to deter predators, shields or protections preventing the assailants either from taking hold of them or from dismembering them. Those among the prey that survive will therefore be taught by the predator. It is because of their status as prey and the chasing by the predator that their kind will evolve and build up the defenses necessary for their survival.

The emergence of the first form of life able to kill another cleaves the world into predator and prey, but these are only the two sides of a single creation. Through their complementary nature, the two can improve one another, surpassing what their kind would be without this new form of struggle, which is as fierce as it is beneficial to life as a whole. The game of predator and prey, of attack and defense, life and death, can initiate a virtuous cycle, forcing all the parties involved to speed up their evolution, forcing them to explore new combinations of bases that would unlock new secrets found in the vaults of life.

The predator plays both sides of the game of life and death, fortifying the strongest, that survives, while offering the weakest of the living to death, excreting their remains as waste that will return to the earth once the living thing has extracted its tribute

from them, in the form of nutrients that will feed its growth. The prey nonetheless also plays an active and essential role in this game. Only if it resists and strives to survive can the game be played and the virtuous cycle continue to pull life further and further up, toward greater complexity, efficiency, and most of all an improved fitness to the place that they inhabit: the sea, and one day the land and the sky. The game would end if an equilibrium could not be maintained between the two players, and so would the refining of life. Such a necessary balance between predator and prey is nonetheless multi-leveled. On the level of individual living cells, the predator will often completely overcome its prey, which will then vanish. The game played between these two players thus ends, but the one played between groups, populations, or species continues, and it is on this level that a proper balance must be found and preserved. If one population of predators exterminates the entire population of prey, the game will stop. With only one player standing, the predator will simply starve, and its branch of life will itself perish.

Like the two poles of the magnets found in an electric rotor, whose play of attraction and repulsion allows the creation of torque on the axis of the motor, the fact that the predator chases the prey while the latter strives to escape from it creates a cyclic force that considerably enhances the evolution of both. There is an arms race between them, and individual predators show no mercy toward their prey, like they show no regard for the preservation of the balance between the players, but because the survival of the predators depends on the existence of the prey, an equilibrium between them will tend to be maintained naturally. If the predators grow too aggressive or too numerous in comparison with the prey available, their reproduction will suffer, and thus their population will later be reduced to an appropriate level. This game, which is one of the main driving forces of life's evolution, of the growth of the tree of life, continues to this day, and every man is, willingly or not, aware of it or not, one of its players. Some have nonetheless decided to reject the game, in India in particular, using the only possible way: to let go of the will to remain part of life, ceasing from killing and consuming any form of living thing, including plants, and therefore slowly advance toward death, in a few weeks' time.² This, however, is an extraordinarily rare exception, as most

²This practice linked with Jainism is known as "sallekhanā", to "thin out."

living things will strive for life until the fire of life has exhausted the strength of their flesh.

The start of the game of predator and prey nonetheless also leads to the emergence of another dimension of the tree of life: a pyramidal hierarchy between living things, according to the way they feed themselves (See Fig. 7.2).³ The basis of this pyramid comprises all the creatures that feed directly on the earth and the sky, and/or power their work of edification of life using their strength. These are the lifeforms examined in the previous chapter: the masters of light, feeding on the envoys of the sun, or those that depend on the blood of the earth, the flow of substances that is poured into the depths of the sea by volcanic vents. The first kind, in particular, still represents the largest part of the great body of life. Hence do they form the widest element, the basis, of the pyramid. They are the producers, those that transform the earth and the sky into life, building it from the ground up. In the case of the light-workers, because of the extreme abundance of the things from which they feed and power their growth, they reproduce easily, and in great numbers.

Immediately on top of the producers, we find the first predators, the living things feeding on them. The subsistence of the predators entirely rests on the existence of the producers, the basis of the pyramid. The producers do not need their predators, but the predators' life entirely depends on the capacity of the producer to perform their work of edification, the assembly of the complex compounds from the rudimentary substances filling the sea, the earth, and the sky, that they need to survive and reproduce, but cannot make by themselves. The predator may have a greater strength, and be able to vanquish any producer, but these feeble forms of life nonetheless hold the keys to the kingdom of life. If they were to disappear, if the foundation of the pyramid of life was to be shattered and to crumble into the abyss, it is life as a whole, all that rests upon its basis, that would vanish into oblivion.

Once again, an equilibrium can be observed in the very struc-

For more information, see: Jeffery D. Long. *Jainism: An Introduction*. Bloomsbury Publishing, 2013. n.p. (Ch. 4, "Sallekhanā: The Fast to the Death").

³In technical language, this structure is usually called the "trophic pyramid." The producers are technically called "autotrophs," whereas the predators are called "heterotrophs," those feeding on various things, including life itself.



Figure 7.2: *The pyramid of life.*

ture of the pyramid of life. The basis may be compressed by those standing upon it, but it remains its widest part, the one that is the most stable and that remains the most essential to the whole. The predators are fewer, but fiercer, taking what they need from what they see as lower forms of life rather than producing it. The shape of the pyramid may at first lead one to think that the upper layer is inherently superior to the lower one, but the relationship between the layers nonetheless nullifies this impression, due to the greater dependency of the upper parts on the lower ones, in addition to the more modest size of the population that they represent. For now, this pyramid only comprises two layers, but others will follow, as it will later be seen. Man will ultimately stand at its top, but if he looks out on the horizon from this most elevated position, all that he will see is the green grass, the trees, and the algae that represent the major part of life, covering the sea and the land. They, the producers, will continue to support the whole of the tree of life. Man would not be able to live without the fruit of their invaluable work of edification, of fabrication of the building blocks of life. Even though he can stand far above them, he should therefore still pay homage to these silent and humble workers, who toil day and night to transform the earth and the air into life, feeding its fire, stealing away from death, without much appreciation or recognition. Life nonetheless does not demand any consideration. It simply grows, as much as the earth and the sky

allow it, and it continues to explore the realm of the possibilities offered to it by nature, unlocking new secrets, new combinations of bases that will allow it to conquer new parts of the earth and become better adapted to its environment.

Re-flection: The Dead Within Us

High is the opinion of man of himself, as he thrones on the crest of the tree of life, and gazes at the extent of his dominion, these weaker forms of life, his servants and his food. Blinded by his proximity with these creatures, he fails to notice the immensity of the earth supporting them, and the vastness of the celestial vault dwarfing both the earth and the tree growing upon its surface. The paragon of life is nonetheless supported by this throne, made of emerald and ruby, leaves and blood, as the green light-workers are the ones feeding all the animals, while he ravenously feeds on them all.

Picking a fresh, edible leaf between our fingers, we let our skin delicately feel the contact with it, touching this myriad of still-living cells, diligent workers of life and skilled alchemists of nature. Gently placing this leaf on our tongue, we let it be soaked with our saliva as our taste buds awaken. The flavor of this living thing begins to penetrate our senses and it is brought into our world by nerves, evoking memories of past experiences and unearthing impressions that we thought were lost in oblivion.

As we begin to slowly chew the leaf, grinding it with our teeth and feeling it torn to pieces, invisible servants of our body in the fluid filling our mouth are preparing its breaking down. Turned into a moist paste, we open up our throat to let this foreign substance enter our stomach, as our senses have properly recognized this living thing as containing what our body craves. The pleasurable taste left in the mouth is a sign indicating that it should not be a poison, otherwise our ancestors would have been decimated by it, lured to envenom themselves by its tastiness.

Our body knows what it needs, as our instincts have been shaped since the first spark of life. Thinking of our favorite dish, salivating at the mere thought of it as we imagine its succulence, most of us will imagine foods that contain some of the rarest and most complex substances, the flesh or products of large fish, fowls, or cattle rather than the omnipresent algae and leaves. These delight our palate because they contain what our body seeks and what is seldom seen in nature and precious, and our ancestors have been selected for their appetite, their craving for what is best for life.

The leaf we ingested is now being broken down by the corrosive fluids in our belly. The fire of life that continued to burn within its myriad of cells is slowly quenched, as their walls are demolished and their machinery dismantled, all becoming a watery pile of building blocks. The unwilling sacrifice of this leaf of the tree of life will nonetheless continue to benefit the middle realm. The wealth of this humble servant of life will not be offered to death, to the earth below. It will rather be transferred to us, remaining part of life and soon once again consumed by it.

We are scavengers and killers, feeding on the flesh of the defenseless, drinking the blood of the innocent. By our nature, we need to extinguish life in order to feed the fire consuming and supporting us, being enslaved by this fire and paying tribute to it daily by offering it the sacrificed corpses of others. We may refrain from feasting on the crimson corpses of beasts, but this only soothes our eyes, as the fruits taken from the trees and the leaves picked on plants remain as alive as we are. Only by fasting completely may we deny our nature as predators, at the cost of a slow, painful return to death.

Accepting our own nature, we may nonetheless be mindful of the sacrifice we perform to remain living. The fruits of the toil of the light-workers, fungi, or animals become our muscles, bones, and nerves. They serve as the pillars of our flesh and our world, and as we perform our daily rituals, we may keep in front of our eyes the image of their devotion to life, the antiquity of their efforts, and thus take care of being worthy of their gift, not squandering their wealth on vanities.

Touching our belly, most of us will feel the blubbery storehouse of our body, coating our muscles. This is the wealth of the producers, the plants and animals that we ate to resist death. This is also, ultimately, the product of the luminous gifts of the sun mixed with earth and air. The excess of it that we keep in ourselves, because of gluttony or fear of death, is a waste of life. When we extinguish life, may it be for its edification rather than its dilapidation, and may we become true gardeners of the tree of life, guiding it by our hands and mind, to the heights.

Chapter 8

Life inside Life: Endosymbiosis

The battle between the minuscule predators and their prey continues to be waged for millions and millions of years. Generation upon generation of them fall and vanish, leaving almost no trace of their existence. Thanks to their incessant efforts, their struggle for the enduring of their own being, the tree of life of which every single one of them is part continues to grow. Out of its trunk, larger branches can now be distinguished, on which smaller ones can be seen emerging. The first springtime of life comes, and new buds can be seen coming out of every new branch, giving the tree an increasingly refined and intricate appearance. Parts of it feed on light, while others draw their sustenance from the blazing veins of the earth. Finally, the youngest shoots reap the low-hanging fruits of the tree of life. They are those finding nourishment in the bark and sap of other branches: the predators, subject of the last chapter. The branches subjected to these attacks may appear to stand idle, but they remain active players of the game of predator and prey, and the playing of this game considerably enhanced the inconspicuous but nonetheless ruthless selection that takes place with the passing of each generation.

Like cats learning to chase mice, while the mice learn to evade the claws of the felines, both predator and prey evolve in accordance with their needs. The prey may, for example, develop ways of avoiding being detected as potential food by the outer wall of

the predator cell, which would not fold itself nor engulf the prey. It may also reinforce its outer rampart, making it either more flexible or rigid, porous or impermeable, by adding a layer made of new substances, on top of the aforementioned lipid enclosure that formed the boundaries of the first cells.¹ Doing so, the cell targeted by the predator may render its absorption and digestion more difficult, by preventing the host's cell molecular machinery from ripping it apart and from penetrating inside the prey. Even if it finds itself being plunged into the body of its enemy, it might be able to survive, and even to overcome the predator from the inside. Like a Trojan horse, an ingested cell may indeed not only resist the attacks of its host but also poison it, or begin to reproduce like a parasite, filling the body of the host and feeding its own growth on the vaults of nutrients of its host, until the children of the prey have consumed them all and burst out of the enclosure forming the predator cell, which would become an empty shell, a decaying corpse ready to be ripped apart and absorbed by scavengers.

Conversely, as the predator faces increasingly defensive and evasive prey, its survival depends on its ability to step up its attack strategies and mechanisms. With each generation, only the most successful at catching and digesting prey survive and reproduce, strengthening their branch of the tree of life. After an astronomical number of infinitesimally small steps, their race evolves and discovers new skills, etched into their very flesh, and whose blueprint is inscribed in their genes, using bases as characters of the language of life. The surface of their outer wall may become more rugged, and protuberances may appear on them, sorts of tiny "limbs" that would facilitate the detection and catching of potential food. It may also fine-tune its internal machinery, creating new substances that would be able to dismantle the hardest walls of the ingested cells, breaking them into pieces that would fuel its growth.

The game of predator and prey was thus played for a considerable number of years and myriads of generations, leading to a faster evolution of both players. One day, a new possibility was nonetheless unveiled as the creatures explored the deeper parts of the vault of life: the fact that they at some point could transcend

¹In technical terms, the inner enclosure, made of lipid bilayers, is called the "cell membrane," whereas the outer part, giving certain types of cells their shape and structural support, is called the "cell wall." Here, the term "wall" will be used for both, not distinguishing between inner and outer parts.

the game and find a way of interacting with each other that would be even more beneficial to both. There are times when struggle brings progress, leading the warriors to surpass themselves, but also others when the rewards of peace outweigh the spoils of war. The players of the game may not have been able to make a conscious decision about it, but through the extraordinary power of the play of affinity and strife, which is the driving force of evolution, a truce was nonetheless achieved between some predators and prey. When the benefits of the strife have been exhausted, an affinity can then develop and be exploited.

The most opportune time to cease hostilities is when there is a clear equilibrium between the two sides wrestling against one another. It is when no one is able to durably overcome the other that the struggles become meaningless and other options can be contemplated. One day, a predator cell engulfed a particularly fierce prey which, even though it failed at evading capture and ingestion, proved itself impossible for the predator to digest, either because its ability to pierce the defensive wall of the prey was particularly weak, or because this rampart was extremely robust. Regardless of the cause, the two opponents in their struggle for survival found themselves in a situation never seen before, a deadlock, with neither winner nor loser, and a game of predator and prey brought to a standstill. It would nonetheless take a great number of such deadlocks before a solution would be discovered. The two players are indeed without awareness nor consciousness, and a discovery can only be made at the level of their species, through natural selection. After many trials and failures, a way out of the dead end begins to appear. With the calm of the standstill and the pause in the game of predator and prey, an affinity emerges between the former players, and the strife that contributed to making them what they are then fades away.

From predator and prey, the two players become host and guest. Their relationship therefore changes radically, with each one of them assuming a new role, which is progressively disclosed and appropriated, across generations. This transformation comes slowly, with the realization, by the species and life as a whole rather than individual cells, that a partnership may now be more beneficial to them both. War gives place to peace, strife to affinity. This affinity may nonetheless take different forms, be expressed in different ways. The host may realize that by opening his pantry

filled with organic substances and by satiating the needs of his guest, he may receive in exchange different substances, which were until now impossible for him to obtain. These may be the wastes of the guest, what is excreted as the end-product of the digestion of the food that it received, but as a dung-beetle, the host may value excrement more than honey or gold.

With each one of them having developed unique needs, feeding on different foods, and fueled by different sources of energy, host and guest may discover that they can embrace each other and form a loop, uniting their bodies to form a single, more efficient piece of machinery, one based on a mutual affinity and reciprocity rather than frontal opposition and conflict. The host may thereby benefit from the abilities of the guest, while the guest enjoys the protection of the host, which is larger, more capable of resisting the assaults of other predators. This marks a fundamental transformation of the relationship between the two parties: when they played the game of predator and prey, the predator improved the species of the prey by killing its weakest elements, while the prey ameliorated the race of the predator by evading the attacks of the feeblest predators and leading them to starve or reproduce in smaller numbers. Now, by becoming host and guest, with a relationship based on affinity rather than strife, they improve each other's species by providing for each other, twisting together their branches of the tree of life, like interleaved threads forming a rope, together more resistant than they ever could be alone. Before, the branches grew stronger because they trimmed each other by fighting one another, thereby cutting off the weakest parts of their enemy, but they now do the same by partnering with each other rather than striving against their neighbor, welcoming each other and twisting their bodies in a loving embrace, thus allowing progress without mutual destruction.

Just like affinities between larger organisms, such as love between humans, the relationship between host and guest may nonetheless also display various levels of power play. The host, in particular, may simply possess the guest and enslave him for his own benefit. Feeding him just enough to survive, he may simply make use of him without offering him any benefit compared to what his life was as he roamed freely in the waters.

No matter how is the affinity between host and guest expressed, and whether or not their relationship is one based on mu-

tual benefit or coercion, the result will nevertheless be the same, as the work of time will play its part, shaping them both equally. As myriads of such relationships are tried, generation after generation, host and guest slowly discover that it is not enough for the former to welcome the latter inside its wall in order for them to live in harmony and help each other. A crucial aspect, one that would allow the discoveries made by them and the progress in their relationship to be passed on to their descendants, is the interweaving of their reproduction mechanism. The guest cannot be allowed to reproduce uncontrollably, as this would endanger the host, which is unable to accommodate an exponentially growing number of inhabitants, but it must reproduce nonetheless, so that the new host born out of the fission of the old one may also welcome a newborn guest, with whom a similar affinity can be developed. The division of the host must therefore occur in harmony and synchrony with the division of the guest. The two processes, which are by themselves already incredibly complex, must be merged, a feat of life that without a doubt took an innumerable number of trials before a single cell could succeed in teaching its ways of interacting with its guest to its offspring.

The integration of the guest within the life of the host is very progressive, the fruit of an intricate work of discovery, performed by a prodigious number of cells. After many generations, the guest begins to lose parts of its own body that are no longer crucial to its survival and reproduction. It abandons some of its outer armor, as it no longer needs to fend off predators since it is now sheltered within the rampart of one of them. The host may nonetheless also cease to live through predation, if its guest can provide it with what it needs to survive and thrive. The affinity between host and guest therefore grows more and more intimate. As both let down their guard and their defense walls become more permeable, they even trade some of their innermost essence: fragments of their genes, the self-replicating chains that define their own being, are exchanged between them. The host acquires some of the characteristics of its guest, and conversely, the guest receives parts of the essence of the one sheltering it. Through these exchanges, themselves subjected to natural selection, the line between them begins to be blurred. Ultimately, the affinity between them becomes so great that the two become one, almost indistinguishable, forming a single living thing.

Once the integration between host and guest is complete, the two become so dependent upon one another that their separation would now imply certain death. The guest has abandoned the means of feeding itself in the sea, as well as the defenses that allowed it to resist predators. The host, on the other hand, is now used to receiving the tribute of the guest, which it uses to feed or fuel its growth. Without these offerings, the cell may not be able to survive for long, as it no longer possesses the knowledge of how to provide for itself, a knowledge that became useless and therefore was not passed on by its ancestors. The fate of the two living things is thus now entangled: their survival is tied to the health of their partner. They nonetheless may be seen as remaining distinct creatures, because they do not share a single essence: their chain of bases, their genes. Exchanges of genes occur between host and guest, but each one of them remains defined by a self-replicating chain² that is unique to them, and remains separate from the one of other living things. The reproduction of both may now occur in synchrony, but the two chains neither meet nor fuse. Like two lovers whose bodies are interlaced and who share the closest form of contact, they form one body without letting their essence be dissolved in this whole that they form. Even after billions of years of coexistence and symbiosis, this line of demarcation between host and guest will be preserved, and each one of them will belong to a distinct branch of the tree of life, which can be traced separately from its point of origin, from the time when the guest roamed free in the vast expanse of the sea, for example.

This process of intertwining of two branches of the tree of life, through the absorption of one cell by another and the mingling of the functions and fate of both is technically called *endosymbiosis*, “living together, inside.”³ For the guest, the change is particularly radical, as it not only implies the weaving of intimate bonds with the host but also being thrown into a completely new environment. The guest is indeed snatched away from the motherly womb of the sea, its home, and forcibly placed inside the walls of the host, bathing in a strange solution whose composition greatly differs from the one found outside, in the free waters that cover most

²Several chains may be used to define a living thing. Each one of them is technically known as a “chromosome.”

³From the Ancient Greek: ἐνδον “within”, σύν “together” and βίωσις “living.”

of the earth. This living thing now lives inside another living creature. It has been cut off from the rest of nature, from the realm of death. It is now insulated from the earth and the sky, and all that it knows is life, receiving its sustenance directly from it and paying tribute to it in exchange for the protection that it enjoys inside, far away from the dangers of both life and death, the hunger of the predators and the rage of the forces of nature.

The host cell represents a small universe, which is largely ruled by its self-replicating chain, but even though the host may appear to “play god” by shaping its guest according to its needs, it nonetheless is far from omnipotent. It possesses its guest but is also possessed by it, and shaped by it, notably through gene transfer. Regardless, the host is like a pregnant mother, harboring in its own flesh another life, nurturing it and safeguarding it from the dangers of the freedom and the uncertainty that lies beyond its skin, its wall. The host acts as a buffer, insulating the guest from direct contact with the forces of nature, belonging to death. Through the service performed by the guest, the host may itself further reduce its dependency on the benevolence of these external forces. The guest may be physically insulated from the outside world, as it lives inside the body of another cell, but this insulation is far from absolute. Exchanges still occur. The walls of both host and guest are permeable to certain substances and forces, and it is because of this that the guest may be able to help the host, performing specialized tasks that it would not be able to accomplish alone.

The realm of all the possibilities opened up by life is an almost infinite maze, a wide landscape of meandering paths that sometimes cross each other, but sometimes also run in parallel toward the horizon, never encountering another. Some of the keys of life can only be discovered on a single, isolated path, and therefore life must be manifold, splitting itself into countless units dispatched across the entire field of potentialities, exploring every path, collecting every key and unlocking every secret. A single living thing, a single branch of the tree of life, would not be able to reach certain parts of this realm on its own. A collective effort is needed. The units first need to take different paths before they can bring the fruit of their exploration together, and then only may they merge their flesh to create a living thing benefiting from the sum of all their discoveries. This is what happens with the advent of

host-guest relationships between living things.

An extraordinary number of possibilities are explored by the free living cells scattered in the waters. Some of them discovered ways to exploit the envoys of the sun, while others took advantage of the wastes produced by other living things. Each one of them took a unique path, which may have been impossible to take by another, but the host cells learn to gather these selfless explorers, whose race sacrificed countless of its members to unveil new possibilities for life as a whole. They can provide a safe harbor for the light-workers, and thereby also benefit from their knowledge of how to exploit the virtually unlimited resources of the blazing orb hovering over the land and the sea. They can also absorb several others of such specialized guests, with each one of them bringing new skills to them. The host can gather all the discoveries made by pioneer cells, combining their expertise and thereby forming a higher form of life, a *meta* living thing that manages several distinct creatures, exploiting their artistry to develop itself.

Each one of the cells of our own body contains one of these guests, which will be the subject of the next chapter. The cells of all plants are also the host of one kind of them: the masters of light, which first discovered the way of harnessing the radiance of the sun, and were at first free living cells, bacteria, that were later on absorbed by other cells, probably similar to the one from which the cells of our own body originate. In our case, our very distant ancestors nonetheless did not choose to engulf such light-workers. They rather welcomed and nurtured another kind of cell, creatures that fed on the waste of the aforementioned masters of light and also changed the destiny of life as a whole, even reshaping the sky in the process.

Re-flection: The Living Within Us

As we sit together with other members of our kind or simply observe them from afar, we are invited to consider both the bonds uniting us as well as the chasms separating us. We often keep mem close because they can give us something we need or crave, whereas many keep to our side for similarly selfish but all too natural reasons. We know we are stronger together, and thus we bind our fate with them.

Strife nonetheless abounds in our world, and it is thanks to it that life still evolves. Permanent and absolute peace implies a lack of competition and selection, and thus, at peace, life slowly decays and is weakened by an overflowing love. Only when strife dances with peace does the tree of life grow, in stature and endurance.

Our ancestors first strove with other branches of life, engulfing entire beings, but once they met a worthy prey, one that fiercely resisted its digestion, they struck a truce and established peace, because it benefited them greatly. Letting a foreign being dwell in their entrails, they became marked by this guest.

Each time one of our cells divides itself, the guest also cleaves its body, and like inseparable friends, each part of the visitor follows a part of the host. Thus did one of them accompany our ancestors since the infancy of life, and the descendants of this most faithful companion still live in each one of our cells.

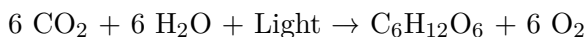
The line between the host and the guest now appears blurrier than ever. These minute helpers may indeed possess their own chain of bases, But they are fully part of ourselves, and we can no longer live away from them. Our body is now made of interwoven branches of life, not only bonded but fused.

We are compound beings, not only made of myriads of cells but also several lifeforms, as once-independent beings coalesced and welded their flesh to make us what we are. Observing our body and those of our neighbors, the birds soaring in the azure sky, the insects creeping on the damp soil, and the beasts grazing in the flowery meadows, we may feel the line separating beings fade away, rejoicing in the unicity of life.

Chapter 9

New Sky and New Life: Aerobic Cellular Respiration

The microscopic harvesters of the sun's light worked diligently for the edification of life for hundreds of millions of years, transforming dead, earthly matter into life and slowly filling the shallow waters, near the shores in particular, where they formed pillars, standing upon the petrified corpses of their ancestors. Besides their ability to harness the strength of the stars, these living things also developed a peculiarity that would later become the source of one of the most radical and long-lasting transformations performed by life upon itself, and also upon the earth and the sky. Powered by the luminous envoys of the sun, they transformed carbon-containing gases¹ and water into sugars that would feed their internal machinery, and rejected free oxygen as a waste product, either into the sea or in the air. Presently, the reaction formula described the labor of such light-workers would be:



These selfless workers are interceders without which our own life would not be possible. They are both mediators and artisans, seizing parts of the sky and parts of the earth, gases and water, and

¹Probably CO₂.

joining them to fabricate new bricks that will serve to build life and enlarge the middle realm, caught between earth and sky, a work that should inspire awe and respect. By borrowing the strength of the fiery orb in the sky to break away the bonds of the substances forming the sea and the air they nonetheless unleashed a deadly force that was until then kept in check by the equilibrium found by the earth and the sky, long before the emergence of life. Oxygen is an element that easily forms bonds with others, desperate to balance the forces in its midst, to pacify the tensions tearing it from the inside. Able to break away the weaker bonds between many other elements and substances, it can force itself upon others, thereby destroying the structures of which they were part.

The free oxygen excreted by the masters of light therefore represents a hazard for the stability of nature: not only for the earth and the sky, that is, the realm of death, but also for life, including the living things that liberated it if they were to be exposed to a high concentration of their own wastes. It would nonetheless seem that for several hundred million years following the emergence of the masters of light, no significant amount of oxygen was accumulated in the air. Different theories have been proposed to explain this fact, among which is the idea that the free oxygen would have rapidly bonded itself to iron atoms dissolved in the sea, which would then have formed an insoluble compound that would have sunk to the bottom and have been buried, preventing any noxious effect upon lifeforms.² For entire eons, these light-workers could therefore have performed their duty without causing any significant imbalance in their environment. At some point, however, the force trapping the free oxygen and preventing it from harming life or transforming the earth and the sky was exhausted.

The oxygen liberated by the masters of light then began to accumulate, both in the sea and in the air. It transformed the methane gas found in the air, some of which was produced by living

²The first article mentioning such a theory is: P. E. Cloud. "Atmospheric and hydrospheric evolution on the primitive earth. Both secular accretion and biological and geochemical processes have affected earth's volatile envelope". *Science (New York, N.Y.)*, vol. 160, no. 3829, 1968, pp. 729–36; For a more recent view upon this question, the reader can see: A. Trendall. "The Significance of Iron-Formation in the Precambrian Stratigraphic Record". *Special Publication from the International Association of Sedimentology*, vol. 33, Journal Abbreviation: Special Publication from the International Association of Sedimentology, Mar. 2009, pp. 33–66

things, into carbon dioxide. One by one, day by day, the minuscule light-workers turned bits of water and carbon-based gases into food for life and threw away oxygen into the sky, used as a dumping place for their waste. At first, it is probable that these workers regularly poisoned themselves when their waste was concentrated too close to them. It would have appeared as if they doomed themselves, as the oxygen would react with both their outer wall and their internal machinery, forcing itself into well-oiled, intricate structures that would break down as a result of this inopportune intrusion. What may first appear as a curse may nonetheless turn out to be a blessing, as what does not kill you makes you stronger, in the words of the German philosopher. Light-workers may have been decimated by the uncontrollable beast that they released upon the world, but once more, a few survived and they passed on their ability to resist the onslaught of this beast to their descendants. This process probably first affected the light-workers, but soon, as the body of the beast grew larger and its reach extended across all the sea, the earth, and the sky, it is the entirety of life that had to learn to fight and resist it.

The mass of oxygen oozed out by the myriad of light-workers represents a river of death flowing over life, corroding what it touches, interrupting the intricate clockwork of the cells, and ultimately taking parts of life back to the lifeless realm, the depths of the earth. The noxious byproduct is like a venomous rain poured onto the tree of life, attacking each one of its leaves, consuming each one of its branches, but a rain emitted by a part of the tree itself. Many of the frailest branches quickly grow putrid and fall down to the ground. The majestic plant is stripped of its glory, as entire parts of life are extinguished by this plague. The resilience of the tree is nonetheless extraordinary and unrivaled. The branches that have survived quickly grow new shoots, which can withstand the continuous downpour of the dangerous fluid. Entire species have been decimated by the beast, perhaps even a large majority of the living things populating the seas and the shores, but thanks to the revitalizing power of the play of affinity and strife between elements, molecules, and cells, through which new mutations can emerge and the most useful ones among these be selected through competition with others, the surviving species quickly discover the means of overcoming the threat presented by the beast unleashed by the light-workers.

Attacking the whole of the tree of life, the noxious rain forces each one of its branches to evolve at a faster pace. Only those that are able to discover a way of resisting the corroding power of this toxic substance survive and remain part of life. The sky is slowly filled with this product of the masters of light, changing its color, which before then probably shone with shades of orange or violet. It now begins to turn blue, as the tint of other gases fades away as they are replaced, leaving only the color of the scattering light of the sun upon the particles of air that hover in the highest parts of the sky. The minuscule living things occupying the interstice between sea and sky have succeeded in transforming the entirety of the sky, as seen from the earth, thereby demonstrating the rising strength of life, which now becomes a true actor in the power-play between the forces of nature, the celestial strife, and is able to stand against the earth and the sky themselves. This feat, marking the first major transformation of the earth and the sky by life, is commonly known as the "Great Oxygenation Event." It became the trigger for a rapid evolution of the entire tree of life, a great trimming, during which many branches were cut out and thrown away to be consumed by death, but this event nonetheless also paved the way for new spring of life, a great sprouting of new shoots that were stronger and more complex than anything that lived before.

The trimming of the tree of life induced by the release of the beasts by the light-workers nonetheless was only a starting point. Life rapidly was forced to live with the corroding substance that filled its environment, but the evolution of these new, more resistant forms of life continued. Some of them not only learned to coexist with this substance but also gained knowledge of how to harness its energy. They discovered ways to tame the minute beasts that crave for bonding, with both the living and the dead, the oxygen atoms that need to establish an equilibrium between the forces tearing them apart from the inside. Despite their modest size, these beasts are indeed mighty and strong, and this is what allowed them to exterminate entire species in the first place. The tension between them and the other atoms with which they desire to bind themselves can nonetheless be exploited by life, just like the strength of the envoys of the sun has been used by the light-workers who unleashed the little beasts upon the world. The two forces will nonetheless be exploited for different purposes by different

branches of the tree of life.

The radiance of the yellow star is used by the light-workers for the fabrication of the building blocks of life, such as glucose, from relatively rudimentary compounds found in the air and the sea. In a similar manner, a new kind of living thing has now learned to harness the strength of the minuscule chemical beasts released as waste by these sun-feeders, but contrary to them, these new creatures will use it to break away rather than to build up, to release energy rather than to accumulate it.³ These pioneers may have been the descendants of the primitive cells that drank the blood of the earth flowing out of the wounds of the planet, that is, the living things that used the energetic compounds poured into the sea by volcanic vents to power their internal machinery. As this blood of the earth was a relatively scarce resource, and a very localized one, these magma-workers were naturally pushed to discover new sources of energy that could power their being. Like for other forms of life, the slow but massive inflow of oxygen probably decimated their population, but the most resilient of them not only learned to survive but also reshaped their own functioning so that they could sever their dependency on the blood of the earth and instead tap into this virtually unlimited new resource, these little chemical beasts that now fill the air of the sky and are also present in large parts of the sea. This marks the emergence of what is technically called “aerobic respiration,” the use of oxygen to turn nutrients into energy, completing or replacing similar processes that used substances found in the blood of the earth rather than oxygen (“anaerobic respiration” and “fermentation”), which are too complex to be described here in detail.

The living things that fed on the blood of the earth, and the other forms of life that relied on similar sources of energy found in the sea, were like small ships tied to a harbor. They were tethered to their particular source of energy, and were unable to depart from it, otherwise the fire of life burning within them would be extinguished and their body would join the realm of death. Once their metamorphosis was complete, certainly after an extremely great number of attempts and generations, and the sacrifice of countless of their ancestors and brethren, they finally began to be

³In technical terms, the photosynthetic organisms use light to perform an *anabolic reaction*, while the aerobic organisms use oxygen for a *catabolic reaction*.

able to exploit the beasts filling up the sea and the air. Doing so, it is as if these ships hoisted their first sail and cut off their mooring lines. They can now set sail on the four corners of the sea, exploring new territories, many of which are then still virgin of any trace of life. Before them, the light-workers conquered vast expanses of the sea and the shores, but their dependency on the benevolence of the sun nonetheless limited their dominion: the sun indeed has to illuminate a part of the earth and the sea before the living things depending on it can occupy it. The beast-tamers, that is, the cells able to harness the power of the free oxygen found in the sky and the sea, are nonetheless not bound by the sun's horizon. What paves the way for their conquest and occupation of a new territory is simply the presence of the little chemical beasts carried by the air and dissolved in water. The abyss of the sea will be out of the reach of the sun, but the beasts are able to crawl into them. They occupy the darkest caves and the deepest creases of the earth, and contrary to the envoys of the sun, they are found there permanently. The light-workers are indeed forced to rest during the night, as their stellar source of energy fades into darkness, but the beasts are dwellers of the earth and the lower skies, and therefore the work they do for their masters can continue night and day, without interruption.

A cascading event can thus be observed, whose trigger was the first harnessing of sunlight by living things. These light-workers released an uncontrollable flow of oxygen upon the sea and the sky, unleashing a myriad of chemical beasts ravaging all that they could touch, including life as a whole. This unleashing, in turn, forced other forms of life to adapt to this noxious environment, including the predators that were tethered to the volcanic vents and the other sources of compounds from the depths of the earth flowing into the sea. As the beast-tamers began to spread, making the pastures of these beasts their dominion, they also invaded the one of the old predators, which remained attached to their source of power, the wounds of the earth where its blood flowed out. Ready to engulf every part of life that they can grasp, without discriminating the living from the corpses, their own kind or other species, they therefore begin to absorb some of the beast-tamers. Once again, a strife is kindled between the two races, and just like the battle between predators and light-workers was solved by a truce and the transformation of their relationship into the one between host

and guest, one of the beast-tamers one day found itself dwelling permanently inside one of these hosts. After many attempts and failures, this relationship became an inheritance passed on from parent to children, with new guests being born within the host and both dying together, their fate tied for the ages to come. As a result of this new union, a new branch sprouted out on the tree of life, one from which most of the living beings now present on the earth descend, including ourselves.

Some of the beast-tamers therefore became the guests of predator hosts. The former gained protection from this new relationship but lost their freedom, while the latter acquired the precious machinery of their guest, the ability to use the energy of the chemical beasts filling up the air and the sea to break down the nutrients that the predators obtained by eating other living things in a far more efficient manner than before, so as to release the energy stored inside these substances, by breaking up the bonds between the elements composing them, an energy that would in turn power their work of edification, their building up of new substances, parts of their body and necessary for their survival and replication. After many generations, the guest became fully part of its host, and both grew dependent on each other, forming a single living thing. The guest became an “organelle,” a tool of the host cell, which is specialized in the release of energy for the powering of the cell’s molecular machinery, commonly known as the *mitochondrion*.⁴

Before the advent of this new, fruitful relationship, many of these predators were chained to the sources of energy that sustained them before their exploitation of the chemical beasts released by the light-workers, incapable of departing for a single day from their home. Now, on the other hand, with their discovery of the knowledge of how to cut off their dependency from this source by powering their digestive machinery with the strength of the chemical beasts populating the waters and the air, these predators now find themselves unleashed upon the rest of life, including the light-workers themselves, who triggered this cascading event in the first place. Untethered, roaming freely in the sea and borrowing the strength of the bath of oxygen around them, these predators can now feast upon the flesh of their liberators, without scruples

⁴From the Greek: *μίτος* (“thread”) and *χονδρίον* (“grain”) and thus named because of its shape (see Fig. 9.1).

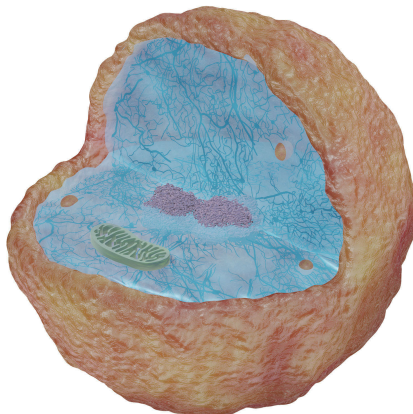


Figure 9.1: *A cell with an oxygen-exploiting guest (in green).*

nor guilt.

The process by which the energy of the waste of the light-workers is harnessed is nonetheless too complex to be described here in detail. The machinery of these “primitive” cells has indeed already grown in complexity and intricacy, and we will therefore only focus our attention on what matters to get a good picture of the nature of these small creatures, our most distant forefathers. What the first predators gained from their partnership with the beast-tamers is more than freedom of movement, a new source of power. Other mechanisms could indeed be used by the cells to release the strength stored inside nutrients, but this particular source has the peculiarity of being especially efficient. It allows them to fully extract the energy stored inside the storehouses filled with the wealth of the masters of light, the fruits of their diligent work, for hundreds of millions of years by a population more numerous as the grains of sand of a coastline. Many of these hosts of the beast-tamers will nonetheless never forget their roots, and they will preserve their ability to make use of alternative sources of energy, when the little beasts released by the light-workers would be nowhere to be found.

As a consequence of the increased energetic efficiency brought by their new guest, the hosts are given an important edge in their struggle for resources with their fellow predators. It then probably did not take too long for their descendants to outnumber the ones who did not welcome the beast-tamers in their midst. They

nonetheless not only overcame their brethren but also conquered new parts of the sea, displacing weaker branches of the tree of life and taking over their dominions. A few of the most ancient branches, for which oxygen remained a poison rather than an energy source, will nonetheless survive the Great Oxygenation Event. They occupy, up to the present day, the places where the chemical beasts released by the masters of light are not present: volcanic vents, soil, or even the guts of animals.

The relationship between the different branches of the tree of life is nonetheless not only based on competition and strife. Just like host and guest found out that living together could be more beneficial to both than struggling against one another, life as a whole finds ways to balance the forces at play within itself. Light-workers and beast-tamers, including the hosts of both, ultimately form a loop, where the former uses a byproduct of the cellular activity of the latter. The beast-tamers indeed use the strength of these chemical beasts, molecular oxygen (O_2), to break nutrients apart so as to release the energy stored inside them. In the case of present-day beast-tamers, the reaction generally follows the following formula:



Nutrients, such as glucose ($\text{C}_6\text{H}_{12}\text{O}_6$), in association with oxygen (O_2) are transformed by the beast-taming guest into energy, usually in the form of a molecule⁵ that is used by organisms to power their cellular machinery, including the human body. Water and carbon dioxide (CO_2) are released as the byproducts of this complex reaction. As said at the beginning of the present chapter, the light-workers use carbon dioxide and water as raw materials to build nutrients, harnessing the radiance of the sun as an energy source for this work. Carbon, the backbone of all forms of life, is held captive by the chemical beasts, that is, oxygen, and prevents it from easily binding itself with other substances, other carbon atoms in particular, as it forms carbon dioxide. The unique skill of the masters of light is their ability to extract such carbon atoms from the grip of their jailers, using the envoys of the sun as shears to cut off the bonds between atoms, so that new substances can be

⁵This molecule is known as *Adenosine triphosphate* (ATP).

formed through their agency. The work of these masters of light follows the following formula:



The work of the two kinds of creatures is of a different nature, as the best-tamers break down nutrients to release energy,⁶ while the light-workers are building nutrients to store the energy offered by the glowing orb in the heavens.⁷ The two are nonetheless looped around one another, as the byproduct of one serves as a fuel for the other. Both branches of the tree of life therefore benefit from the existence and the work of the other. Once again, branches grow together in harmony, intertwined, thereby strengthening each other, like a bundle of interlaced threads. Life finds ways to adapt to any change in its environment, no matter whether this change is brought on by the earth, the sky, or by a part of life itself, as is the case here. Threats are turned into opportunities to discover new possibilities, fertilizing the soil out of which the tree of life grows, encouraging it to extend its branches further and further up, away from the earth and toward the sky, far from its roots and toward its destination.

Such an equilibrium, with the wastes of one branch serving as the energy source of another, endures to this day. Both plants and animals such as ourselves are the descendants of the first predators, but each one of these two branches has inherited a particular role. Plants are the hosts of light-workers, while animals have beast-tamers as their guests. The former needs the carbon imprisoned by the chemical beasts found in the air (as CO_2) and reject these beasts (O_2) as a byproduct of their work, while the latter needs these beasts as a source of energy and release carbon imprisoned by them as a waste. This circuit within life itself therefore has endured for most of its history. Life has found a proper balance of its reserves of both substances, which are stored in the celestial vaults, as without such an equilibrium, the largest branches of the tree of life would swiftly find themselves threatened.

As shown by the story of life, even if the loop between light-workers and beast-tamers were to be cut off, and even if the storehouses in the sky were to be emptied, the incredible resilience of

⁶This is technically called a catabolic reaction, or catabolism.

⁷This is technically called an anabolic reaction, or anabolism.

life, driven by the play of affinity and strife, reproduction and selection, may simply cause this event to be the source of a new (r)evolution, which may strengthen and embellish life even further. Such an event may destroy our lives, our races, and our kind, but others would replace and perhaps outperform us.

Life is nonetheless not on its own. The other major forces of nature play an important role in the balance between the various resources that life needs in order for its fire to continue its work of combustion. Just like the chemical beasts, oxygen molecules, which find themselves going in and out of life, caught in a cyclic current bringing them up into the sky and down into the sea and inside life, through the action of the winds or the sun, for example, others substances are also caught in such a flow. Carbon is itself handled by the beasts released by the light-workers and is part of their cyclic motion, but others such as nitrates are also resources needed by life that are in part managed by the forces of nature, through similar cyclic movements in the sea, the earth, and the air. Earth and sky are the cradle of life, and also their parents. They nurture it, feed it, and ensure that it develops itself in number as well as in strength, refinement, and adaptability. The wealth of the earth and the content of the celestial storehouses are like a lump of dough, vigorously kneaded by the forces of nature, brought up into the highest sky and down into the deepest abyss of the sea, again and again, so that the invisible creatures in contact with this dough may be able to feed on it, like yeasts. The continuous and multifaceted whirlwind bewitches the sea, the earth, and the sky, allowing the mingling of their ingredients, of their wealth. Even the distant star participates in this work, as the heat it radiates stirs up the winds and directs the scattering of these ingredients covering each part of both water and land. This astonishingly sophisticated ballet of nature represents a stage on which the play of life is unfolded, with the third realm in a state of constant reaction and adaptation to this ever-changing stage. For now, however, life is only in its infancy. A long path still has to be walked before it matures and creatures such as ourselves can emerge out of the earth, out of death.

Re-flection: The Beasts Within Us

Each day, we are the witnesses of the unceasing revolutions of the wheels of the skies, as the dark gives place to the bright at dawn and the heavens wear their azure vestment. The story of this garment should also each day be kept in our mind and heart, and as our eyes behold the emerald blanket of the earth, the green leaves and grasses, we should remember that it is their ancestors who built this crystal-clear, life-sustaining storehouse.

The plants are not mere sources of nourishment for our kind and other animals. They not only produce food, transforming death into life to nurture the tree of life, but also fill up the air with the fluid that we breathe and desperately need to live. The molecular beasts, the oxygen they have been storing in the celestial vault, allow us to efficiently unlock the energy encapsulated in our food.

Long before our ancestors had lungs and airways, they welcomed this wealth of life, as they engulfed a creature that discovered the secret of its exploitation. Now living inside the walls of our forefathers, becoming one with them, their unique skill benefited the whole that they formed, giving them strength.

The descendants of this first guest are present in our cells, living inside us, being fully part of our body and yet conserving their unique, separate chain of bases. Taking a deep breath, we give them work, as myriads of minuscule beasts pervade our flesh. Patiently, each guest unlocks the energy stored in the form of sugars and fats, Powering the machinery of our body and supporting our life, prolonging our time outside death.

If we can now walk the earth and enjoy the freedom of living anywhere the winds blow, it is because the light-workers paved the way by offering us their precious product. If we can grow so large and strong, it is also because of the contribution of our guests, the minuscule things allowing us to exploit the wealth filling up the sky. We form a whole with the other branches of life, and should not forget it, leaving behind arrogance and the belief that we tower above other beings.

Breathing once again deeply, let us recognize that this air that fills our chest, it is the fruit of the work of the light-workers,

perhaps undertaken eons ago. They turned light into leaves, fruits, or nuts, delighting our tongue and belly, but they also give us the means of breaking down their flesh to power our own.

As we expire, we may remember that we nonetheless also offer them something back. The air going out of our mouth has been depleted of its oxygen, precious to us, but it has been filled with carbon dioxide, a byproduct of our respiration, and our waste is precisely the substance needed by the light-workers to perform their work of alchemy.

Contemplating the distance between us, the plants, and the skies above us all, we may also notice what unites us, the cycle binding us together and strengthening us. The emerald light-workers feed on the breath of the animals roaming the earth, while we breathe what they excrete, both using the celestial vault as a granary.

The air enveloping us each day of our life is the cement binding us to the emerald ones. The fate of our kind is now inextricably linked with these distant cousins, as we would no longer survive for more than a few instants, and swiftly rejoin death, if we were to be separated from this wealth of the light-workers filling up the sky. Aware of our dependency on them, we may acknowledge our weakness and be grateful.

Chapter 10

Cores and Shell: Eukaryotic cells and Compartmentalization

The unleashing of the oxygen beasts upon earth and sky decimated life, but it thereby also fertilized the ground in which the tree of life plunges its roots, giving it a new impetus, allowing it to promptly grow in new directions. Cells found ways to harness the strength of these beasts for their own edification, but by welcoming them inside their border, their outer wall, they also allowed their flesh to be devoured by them. The beast-tamers indeed learn to perform their work and serve their host, but the beasts nonetheless invade the cell in great numbers, penetrating every retrenchment, occupying every space, and entering into contact with every cog in the cell's machinery.

Like a red-hot ember, the minuscule beast can bring energy when it is placed in a furnace, in a place built to withstand its force and use it for a precise purpose, but if it is thrown on a person or a piece of wooden furniture, it will only be the source of irreparable damage. Life, at this point at least, does not possess the intelligence necessary for it to directly learn to discriminate the useful from the noxious, the benign from the destructive. Life is nonetheless far from powerless. Its intelligence is deployed through the succession and selection of generations, sacrificing a great number of its children in order to discover, through trial and failure,

the keys of a greater fitness to its ever-changing environment, a closer relationship with the earth and the sky, the forces of nature that guide and nurture the growth of the middle realm, through their continuous, transformative flow. The beasts are at this point in time born on the surface of the sea, where the light-workers silently stand on the separating plane between heaven and earth, patiently harvesting the luminous envoys of the sun and using their strength to liberate the beasts bound to the carbon in the air. As soon as a litter of new beasts is born out of the light-workers, some of them run into the depths of the waters and penetrate the ramparts of the cells inhabiting the sea. As soon as they pass through the ranks of aligned lipid molecules forming the wall, a war begins between them and the inhabitants of the cells, the multitude of substances that form its internal machinery.

A merciless war is declared by the beasts inside each living cell, one which does not cease even when the beast-tamers succeed in harnessing the strength of many of them. Each one of them probes for weaknesses, ripping apart the chemical structure of the substances forming the cell, from its outer wall to its center point. At the same time as life was learning to tame the beasts, each part of the cells subjected to the invasion struggled to fend off their assaults and collectively discover ways to prevail over the toxic entity. Victory demanded tremendous efforts from life, and the sacrifice of a formidable number of cells. The composition of many substances forming them had to be modified to resist the onslaughts. Proteins, servants of the cell, evolved to avoid undesirable reactions and bonding with the beasts now roaming freely within the walls. As an incredible number of combinations were tried through random mutations of the cell's self-replicating chain, many cells were snatched away by death. The fire of life was extinguished within them, as the gigantic machinery powering their being broke down under the influence of the dangerous beasts, which caused the collapse of previously stable structures made of atoms and molecules. This total war between the beasts and the parts forming the cell favored a rapid growth and branching of the tree of life, as the living things exhibiting new features allowing them to resist the invaders thrived while the rest of their brethren returned to death. The survivors were radically and durably transformed by the invaders, even leading to the emergence of entirely new structures within their descendants.

The most critical part of the cell, the one without which no life would be possible, and which is the most sensitive to attacks certainly is the self-replicating chain, on which the genetic code defining the cell is inscribed. Most cells have slightly different chains, due to the continuous and necessary appearance of mutations, which allow the discovery of new facets of life, but they also are the direct descendants of a long line of cells, each one of which carefully preserved the innovations that allowed their ancestors to out-breed their competitors. Each piece of the chain is the result of a long process of selection, and the different parts of the chain are often intertwined, with the slightest change of one potentially having tremendous repercussion on the whole destiny of the cell, as it is built using the information it contains. Each instant, the fire of life burning inside many cells is extinguished as the result of the random mutations of their chain during replication, but such mutations remain relatively rare, occurring at a rate which itself has been finely tuned through natural selection. The beginning of the war between the cell and the beasts nonetheless severely upsets this delicate order, in which randomness and errors are offered a place within life and help its edification.

When the beasts enter into contact with the self-replicating chain, which for now floats freely within the walls of the cell, its arms embracing and touching the various elements forming this living thing, it is like the rest of them, subjected to the continuous assaults of the invaders. The venomous substance can force itself inside the backbone of the chain or the bases with which the code is written, reacting and binding itself to atoms that crave an affinity with it. It thereby corrupts the integrity of the chain, scrambles the information that it contains, impairs its replication, and ultimately may undermine the entire organization of the cell, whose survival depends on an astonishingly complex choreography performed by its chemical servants, proteins in particular, which themselves rely on the information of the chain. Furthermore, contrary to several parts of the cell, such as the beast-taming guest, whose machinery is enclosed in the remains of its former outer wall, the chain has no protection. It is laid bare inside the watery environment found within the walls, without any defense nor guards. Attacked by the beasts that are forcing themselves upon the chain, bewitched by a destructive affinity between atoms that threatens the affinity between the larger structures forming the chain, the cell's library of

information can only minimize the damage it suffers by curling up on itself, forming a huddle and only exposing its least vulnerable or critical parts on its outer surface, keeping the most essential ones safely hidden in the center of this mass of knotted threads of chemicals.

The chain nonetheless remains headless. It is still a mere series of bases fixed onto a linear frame, without awareness, nor any control over the way it folds itself. The templates of numerous vital elements of the cell are therefore ineluctably affected by the assaults of the minuscule beasts, but fortunately, the whole of life continues to work to adapt and discover new ways of improving its defenses and establish a truce with these new, barbaric dwellers of the seas and the sky. Life recognizes their usefulness, the value of the contribution that they can make to the cells, and to the tree of life as a whole. It must simply find a balance within the microcosm of the cell, offering the beasts a pen within its walls, without letting them wreck its most critical structures.

Experiments are then conducted by life, powered by random mutations of the self-replicating chains themselves. The cells that fail to find new ways to protect their chain often degenerate after they reproduce, as they give birth to mutants with a severely altered code, which is corrupted by the beasts attacking it. These grotesque creatures then develop an incomplete or aberrant structure, becoming a misshaped piece of machinery that is unable to function properly and ensure the survival of the cell, let alone allow it to produce a viable offspring. Others nonetheless make new discoveries, and one cell, in particular, one day found out that old tricks can be the source of new innovations. Just like the chain of one of their most distant ancestors first found protection from the threats permeating the sea by finding refuge inside an enclosure made of lipid molecules arrayed into a spherical wall, one of its remote descendants used a similar process to form new layers of protection, within the body of the cell itself.

The chain now finds itself held together by a relatively solid sphere, whose structure is intertwined with it and which plays a key role in processing and making use of the library of information contained in the chain to produce the different substances and elements of the cell's machinery.¹ All around this holy of holies of

¹This innermost structure, the core of the core of the cell, is called the

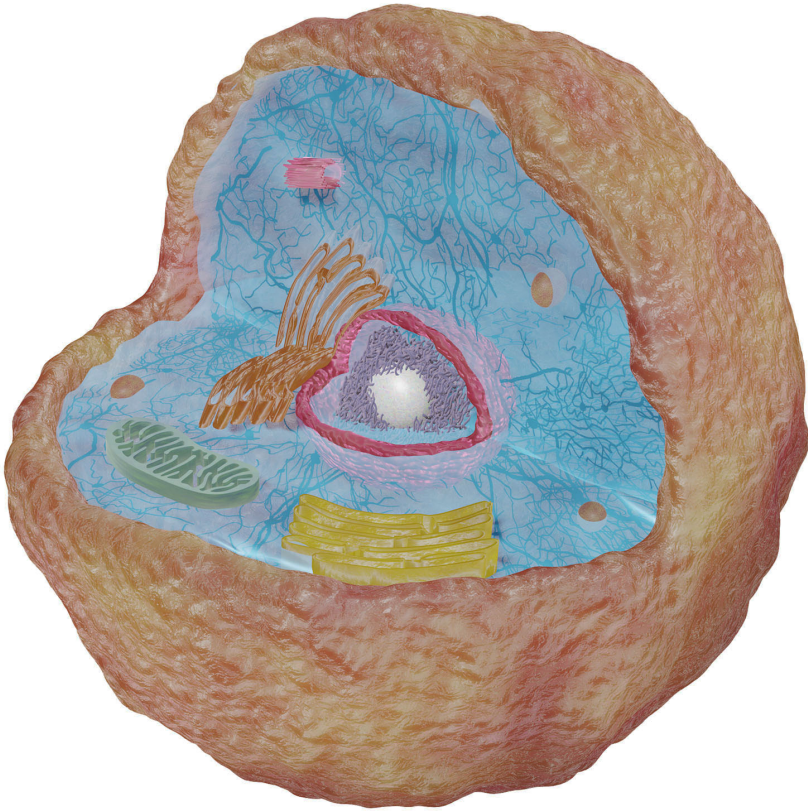


Figure 10.1: *A compartmentalized (“eukaryotic”) cell.*

the cell, the chain protrudes, like a dense tuft on a head, but this is where the new enclosure is built, encompassing the entirety of the chain, enshrouding it in a protective veil of lipids. The precious library of the cell, as well as its most crucial servants, the chemical librarians and commanders that select bits of information from this storehouse and dispatch them all around the cell so that new servants or substances can be built following these blueprints, are now sheltered from the content of the cell, isolated from the beasts that roam freely within the outer wall but are kept away from this sacrosanct shelter.

The cell now has a core, located at the center of its spherical wall, dwelt by the self-replicating library and the innermost circle of workers handling its knowledge, with ranks of lipid guards fil-

nucleolus.

tering with great care what can enter into contact with this most critical part of the living thing. This compartmentalization of the cell marks the emergence of a hierarchy, with the core acting as a central command. This central nature is both physical and symbolic. The core is at the center of the spherical cell, but it also represents the starting point of its being and of all the processes that regulate its life. Through natural selection, life therefore discovered that a reorganization of the general topology of the cell would be to its advantage. The central and crucial role of the library is finally recognized. Its place now reflects its importance, and so does the care with which the core is separated from the rest of the cell.

The living thing was like an orderly village, an assembly of randomly located buildings populated by men of all backgrounds and positions bumping into each other and sharing the same space in relative equality. As life explored countless different ways to organize this village, it naturally discovered that by creating separations within the inner boundaries of the outer wall of this chaotic hamlet, it could better resist the assaults of invaders and be able to outperform its neighbors in the struggle for survival and reproduction. By breaking the equality between the different parts of the cell, and instituting a rigid hierarchy allocating more resources and a better location for the most essential parts of it, the whole of the cell can become stronger, more adapted to the ever-changing flow of the earth and the sky.

The village is transformed into a city, centered around the library, in which the innermost circle of chemical leadership lives a life of seclusion, insulated from the hustle and bustle of the things toiling beyond the walls of this holy of holies, this temple of knowledge from which messengers are sent so that the orders issued within it can be carried out all around the walled town. The servants of the city who have access to the library are thus elevated above the rest of the population, which is thus cleaved in two. The dwellers of the core, the palace around which the whole city gravitates, represent a higher class, the members of an elite, which take decisions affecting the whole of the city, with an army of messengers delivering their orders to the lower class, which are swiftly executed, without emotion nor awareness. The members of the elite, living sheltered inside the core, protected from the assaults of the beasts that are enslaved by the city, their energy patiently

harnessed by the beast-tamers, nonetheless possess no more awareness nor conscience of their role, which is played mechanically, or rather chemically. As always, the intelligence of life may only be observed as manifesting itself in the whole of the tree of life, and the natural forces that guide its growth: the earth and the sky. Each branch of the tree nonetheless continuously evolves individually, standing out more and more from its ancestors and others branches, with the living things belonging to it developing a more complex architecture following new discoveries brought on by the play of mutation and selection, affinity and strife, when such complexity increases their chances to reproduce and out-breed competitors. The elite and the library are therefore the center, but not the brain of the cell, and its capacity to evolve depends on larger forces, whose action is spread across entire populations and many generations.

Keeping this in mind, the evolution and transformation of the cell can be acknowledged. The newly established hierarchy can be seen for what it is: it does not represent a sudden power grab by random dwellers of the village-cell, a revolution leading to the establishment of a feudal relationship between formerly equal members, where an elite would rule upon plebs condemned to obey their every whim. The new division, expressed firstly as the construction of the core's twofold enclosure and secondly as the centralization of all that is found within the outer wall around this core, is not the result of the will of dwellers of the city, as none of them has any, but rather the fruit of an organic, natural evolution, the product of the discovery by life itself that this particular arrangement and organization, transforming the chaotic village into a more orderly city, allowed the cell to live more harmoniously with the chemical beasts pervading the sea and invading the city's rampart. In this particular case, division and hierarchization would allow this branch of the tree of life to recover from the threat posed by the unleashing of the beasts, and to arrange a truce with them.

The war between this group of cells and the beasts therefore ends. The battles waged by the beasts often ended in the complete annihilation of entire branches of the tree of life, but in the present case, the two enemies learned to coexist, with the cell successfully exploiting the invaders. The energetic efficiency of the cell grew tenfold thanks to their work, and it therefore can easily prevail when competing with other forms of life, when resources

are scarce in particular. Its advantage is so great that its direct descendants today represent the major part of life. Every single cell of each animal, plant, or fungi that has ever lived has inherited the compartmentalization and hierarchization of the cell discovered by a single pioneer of life. These form the *Eukaryota* branch of the tree of life, composed of cells with a “well (defined) core.”² The presence of a core is nonetheless not the sole feature defining this new branch of the majestic tree. Our knowledge of the timeline and sequence by which these other features were discovered by life remains very patchy, but one thing appears established: the common ancestor of all the aforementioned domains of life possessed such a structure, which we will now briefly depict.

The compartmentalized cell, as it is known today, probably emerged after a long period of maturation, with many intermediary stages whose traces have been lost in the flow of time. Its structure is considerably more refined than the one of its known predecessors, comprising an extremely intricate set of elements all working together to overcome all the challenges posed by life on earth. The core, with its library of information and its diligent elite workforce, is at the center of a convoluted network of extremely fine tracks and slightly broader roads made of filaments braided by the servants of the cell themselves, on which chemical messages can be carried and substances be delivered to the four corners of the walled city. This indispensable web allows efficient communication and cooperation between the numerous actors, each playing a crucial role in the life of this community. These actors, elements of the cell, are no longer floating aimlessly within the watery environment present within the wall, but are rather kept in place by the web of filaments that pervades its entirety. It represents a frame, a skeleton, just as much as a road network, bringing more stability to the structure of the cell, and therefore greater predictability, necessary for well-organized processes to emerge.

Anchored on the web of filaments, new, specialized facilities have been developed by life. One of them is located close to the library’s wall, with openings allowing exchanges between the two to occur.³ Serving as a sort of factory, it receives orders directly from the servants in the library and fabricates many of the raw

²From the Greek εὖ (“well”) and κάρυον (“kernel”).

³This factory is technically called the endoplasmic reticulum.

material and protein workers needed in the whole city. It appears as a mass of wrinkled layers folded upon themselves, enfolding parts of the core (In orange, next to the core, on Fig. 10.1). Inside it, a labyrinthine network is found, filled with skilled chemical workers who are selflessly toiling to weave long chains of amino acids into proteins, adding each one of them one by one, following a template stored in the library and whose copy they received from the scribes who have access to it. This weaving is nonetheless only the first part of their work, as these long chains then need to be folded into a three-dimensional shape, with each atom forming it playing the game of attraction and repulsion, thereby transforming the chain into a machine that will itself work for the benefit of the cell. Once weaved and folded, these products are then packaged and dispatched where they will be needed, following the paths and highways that cover the totality of what is found within the outer wall, and they begin to play their part in life.

Some of the products are nonetheless further processed in another facility, more distant from the center of the cell. It resembles the first, a stack of folded organic fabric, a maze of passages and openings teaming with chemical activity (In yellow on Fig. 10.1).⁴ Enclosed in vesicles sent by the first factory, the facility receives its products and once they are unpacked, stripped of their lipid wrapping, they are then transformed, refined, and their final destination is determined. Chemical signals, labels, are attached to them and they are further dispatched, soon reaching the place assigned to them.

The walled city contains numerous other specialized structures. There are pouches where the foreign matter absorbed through the wall, either belonging to life or death, is disassembled, torn apart and turned into its basic constituents, which will be used as raw material for the factories building new parts of the city. There are waste processing facilities, where noxious substances can be neutralized, and superfluous ones simply gathered before they are all expelled from the city, too crowded to accommodate useless things. Finally, there is a center in charge of the reorganization of the network of filaments forming the cell's road system and frame. Taking the form of a set of tubes themselves made of

⁴This facility is technically called the *Golgi apparatus*, named after the scientist having discovered it.

smaller threads, bound to the network of filaments pervading the entire cell, this structure participates in the rapid reorganization of the entire cell that takes place during its replication and division, facilitating the distinction and separation of the two copies.⁵

The evolution of the cell followed a path of increased complexity, and specialization. The urban metaphor comparing this new type of cell to a city can be developed further, as the resemblance between the two can also be observed in their evolution. Later in the history of life, when groups of men living in small bands of hunter-gatherers or farmers created larger communities living in highly ordered cities, this led to an immediate hierarchization and specialization of their inhabitants. A breaking of the relative equality shared by them occurred. Leaders of course always existed, even in rudimentarily ordered groups, just like the library always played a prominent role in life, but now it is also marked by a spatial, physical separation, in palaces of marble or inside lipid spheres like the one forming the core of the cell. Freed from the need to directly find all the substances that the worker needs for his survival, such as food or energy, which can be procured by other members of the community in exchange for their service to it, he can invest all his energy and knowledge to develop skills that would not be possessed by others. He can take time to practice what he already does best so that he can discover new techniques and thereby bring a greater contribution to the community, which will find itself strengthened by his innovations. Specialization allows the focusing of one's energy and work on a single task, more precision and efficiency, and this is why cells adopted a city-like structure through the power of natural selection, and why men started to build cities, because of their realization of this fact, using their own intellect. As with all things, however, such progress comes at a price.

A city is strong, reactive, more able to adapt itself to a changing environment or to resist the onslaughts of outsiders than a primitive village. Each one of its dwellers is part of a complex system, a piece of well-oiled machinery that is built to maintain and develop the community. A great cohesion between each part is necessary in order for it to function properly, but it also comes with

⁵This structure is named the *centrosome*, composed of smaller structures named *centrioles*.

a drawback: a complete dependence of the parts on the whole. The visitors of the city can no longer step out of its walls, like the guests taming the beasts inside the cell, which are now unable to provide for their most basic needs by themselves. Just like cities ineluctably prevailed over villages, the highly organized cell nonetheless also crushed its competition, only leaving a few niches to more rudimentary forms of life, the most inhospitable parts of the earth and the sea, such as those without beasts whose energy can be harnessed, without light to be exploited, the places without air nor light. The tree therefore continues its slow but continuous growth, with new shoots more refined and complex than anything that came before them, like sophisticated flowers with perplexing geometries, whose incomprehensible nature only adds to their magnificence.

There is still one more crucial advantage of the new structure of the cell. As the library of information at its center is now enclosed in a protective envelope, its content can now be packed more tightly. Freely floating inside the body of the cell, an excessively large amount of information would indeed take so much space that it may hinder the functioning of some of its other parts, but now that this library has walls, its content can be kept inside, protecting itself from what lays outside. Safe from the harm of the beasts but also other threats such as the envoys of the sun and other celestial bodies, the content of the library can also grow larger. With the number of mutations kept to an optimum amount, neither too large nor too small, discovered through selection, the chain defining the cell's structure can store the blueprints of new features, new discoveries. So enormously long if unfolded,⁶ it is like a house of cards, threatened to be blown away by the gentlest breeze. Only when isolated from the outside, safeguarded inside an enclosure, can it take larger proportions and serve as the source of information for the edification of more complex forms of life. This probably explains the remarkable success of this precise type of cell, which now overwhelmingly dominates the whole of life. This, however, is only the starting point of the spectacular saga of core-containing cells.

⁶Unfolded, the DNA present in a human cell can measure up to 2 meters.

Re-flection: The Walls Within Us

Countless are the blessings we receive during our life from benevolent nature. We are bathed with light from the heavens during the day, showered with water, while the darkness of the night offer respite to our senses and a refreshing breeze. Nature nonetheless remains a formidable force, one that can crush us all in an instant.

The gusts of wind blowing over the earth may bring us the air we need to breathe, but a delicious food may also be poisonous. A medicine may heal and harm at the same time. What is powerful is also dangerous to handle, and so is the wealth of the sky, as the molecular beasts inside it power our body but corrode it as well.

Observing their work on a piece of iron, the unyielding metal of our knives and hammers, we witness their inconspicuous power, robbing the shiny iron of its glare, transforming the rigid mass into crimson flakes that crumble under our fingers. They make iron bleed, and they cause our skin to wrinkle and dry out with age.

The work of these beasts has shaped our cells while life was still young, and each one of these cells now shows the traces of their intervention. Looking at the skin of our hands, touching it gently with our fingers, we may imagine the trillions of them forming the mass of our body.

Each cell is now a perfectly organized machinery, one that uses the beasts, containing them in selected areas, using them without letting them cause damage. The libraries of information are now well-protected at the center, the core, ensuring that the inheritance of our most distant forefathers can be passed on, and that the work of the cell may continue without hindrance, until death comes.

As a result of the permanent and omnipresent aggression of the beasts upon life, our distant ancestors witnessed a merciless slaughter of their relatives, while they survived by evolving, organizing their entrails more efficiently. From a disorderly village, the cell became a highly complex and ordered city, replete with specialized structures and skilled workers performing unique tasks.

Having received their discoveries as our inheritance, directly passed on to us, we may imagine the hustle and bustle occurring

right now inside our body. An astronomical number of molecular workers busy themselves to sustain us, coming and going by following roads made of long filaments braided by the cell.

They toil in specialized structures, to build substances or to break them down. They welcome things coming from the outside or reject accumulated waste. Continuously weaving molecules and folding them into new servants of the whole, each cell may be seen as a miniature image of the fullness of our body.

Like the whole that we form, our cells may feed and excrete, breathe and choke. The stomach and entrails digesting what we eat are mirrored inside them, and so does the network of veins and arteries that carry substances around our flesh. We may imagine each one of them as a miniature body, striving to stay alive. Their core, with its library of information containing the knowledge of our bloodline, they would be the image of both our genitals, including our seeds, and our brain, the two most important parts of our body, with one often (con)fused with the other.

The image of the cell may nonetheless be further enlarged to appear more clearly, as we may see its reflection while we observe the city surrounding us now. We are the workers of this city and the roads we walk are our network of filaments. The factories in which we spill sweat and blood are where things are fabricated, whereas the city hall is the core where the life of the community is planned.

As we play our part in the life of this city and in the whole of life, the innumerable servants of our cells play the role assigned to them by life itself. All work in unison for the growth of the tree to which we all belong, and as we picture their inconspicuous but important contribution to our being, we may reflect on whether or not we are worthy of their titanic and selfless work, whether or not we measure up to their boundless devotion to our existence.

Chapter 11

Life in Motion: Flagellar Motility

Life is a whole made of parts, whose number has grown larger and larger with each passing day, during most of its history. Its growth is only reined in by the earth and the sky, which provide for it, but whose resources are limited. The body of life takes eons to spread itself over the earth, but the pace of this action is nonetheless steady and rarely slowed or reversed. It now covers a large part of the skin of the earth and the depths of the seas. Like a mass of liquid spilled on a floor, life slips into any interstice, burrows into any crevices, and invades any chasm. Life continuously moves, from the smallest particles forming each one of the individual living beings composing it up onto the entire tree of life, but its movements are until now entirely guided by the earth and the sky, its considerate parents, whose hands are nevertheless themselves simply obeying the most fundamental forces of the creation.

The liquid spilled over the earth, the water forming the body of the sea, behaves like the mass of all the beings forming the whole of life. All follow the furrow carved for them into the fabric of the universe by the play of attraction and repulsion, played in multiple dimensions, mediated by different forces, with each one of them bearing a distinctive name: gravity, the electromagnetic force, the weak and strong interactions between elementary particles. The unceasing unfolding of the play of attraction and repulsion, which takes place at each instant on these different fields, themselves in-

terwoven one into the other, is the source of the permanent tumult of all that fills up the sky, including the whole of life itself. The middle realm nonetheless possesses some peculiarity that makes it stand out from the earth, the realm of dead matter.

Life invades new territories as living things are carried by the currents of the deep or the loftiest winds, the hands of the earth and the sky, but it also conquers through its growth. By reproducing themselves, living beings are birthing other beings into new parts of the earth, which they will make their own. Contrary to the earth, which does not grow by itself, life relentlessly works for its own enlargement, being the source of an impetus that stands out from the rest of the com-motion of nature. Life moves by itself, from its first spark, through its capacity to give birth to new beings out of itself. The whole of life should nevertheless now be distinguished from its parts, the individual living things forming its body.

The living things that have been examined in the previous pages are the humblest, most primitive forms of life known to us, but they remain true wonders of nature, astonishing feats of complexity and refinement, unsurpassed by any creation made by the hands or created by the mind of a man. Their internal machinery is bustling with complex movements, an endless ballet of perfectly executed actions by the workers of the cell, the complex molecules that make the bulk of life, and yet, these cells are at this point essentially powerless when they are seen individually. Life already stands up to the largest forces of nature as a whole, as demonstrated by its capacity to reshape the composition and hue of the sky by its unleashing of the molecular beasts called oxygen, but on their own, individual cells are like driftwood on the ocean. Their fate is entirely in the hands of the currents carrying them, as the countless parts moving within the wall marking the boundary of their body are incapable of extending their work beyond its limits. The continuous com-motion that takes place inside the cell cannot be translated into a coordinated motion. The cell is for now condemned to remaining a passive element, even though it is part of the whole of life, which itself is already an active player of the power-play between the forces of nature.

The cell therefore represents a passive structure caught between an active sub-structure, with its internal parts in constant activity, and an equally active meta-structure, the tree of life. The

cell is itself made of a myriad of actively moving pieces, and the whole of life formed by all the living things also is endowed with an ability to move itself as a whole, through reproduction and growth in particular. Between these, the individual cell, for now, nonetheless remains passive, unable to take its destiny into its own hands by actively moving through the seas, to oppose the flow of the currents and winds that carry it wherever they choose, except by dividing itself to generate another cell. Each branch of the tree of life nonetheless continuously grows, and one of them will soon discover a way to extend the com-motion reigning inside the cell beyond its wall.

A crucial element that allowed the cell to liberate itself from the prison of its own immobility is the aforementioned network of molecular filaments, the roads used by the city's workers to deliver substances and messages to all the facilities present in its midst, in addition to providing structural support. The worker metaphor designating some of the proteins of the cell is particularly appropriate here, as these complex and yet extremely small molecules, made of a few dozens to a few hundred atoms, are often endowed with what appears as tiny arms and legs, and which have the exact same function as ours. Powered by the energy accumulated in chemical form by the cell, mostly as a reserve of *ATP* molecules,¹ these workers are capable of moving their limbs cyclically, as they are bent following their reception of an energetic molecule, which fits into a particular "site" thanks to the play of attraction and repulsion, and then take back their original shape when this molecule, whose energy has been spent, is ejected to be recharged, by the beast-tamers in particular. This is somewhat similar to the way the light-workers harvest the energy of the envoy of the sun, but the process has here been finely tuned and adapted, so that this energy is used to produce a mechanical motion.

Some of the workers therefore walk on the convoluted web of roads, weaved with the finest threads. Their feet follow the road because of their particular affinity with it, as both fit into each other like a lock and key, according to a particular pattern of attraction and repulsion between the atoms forming them, as it was the case with the complementary bases forming the self-replicating chain. Thanks to the work of other types of such "motor

¹ATP is the abbreviation of *Adenosine triphosphate*.

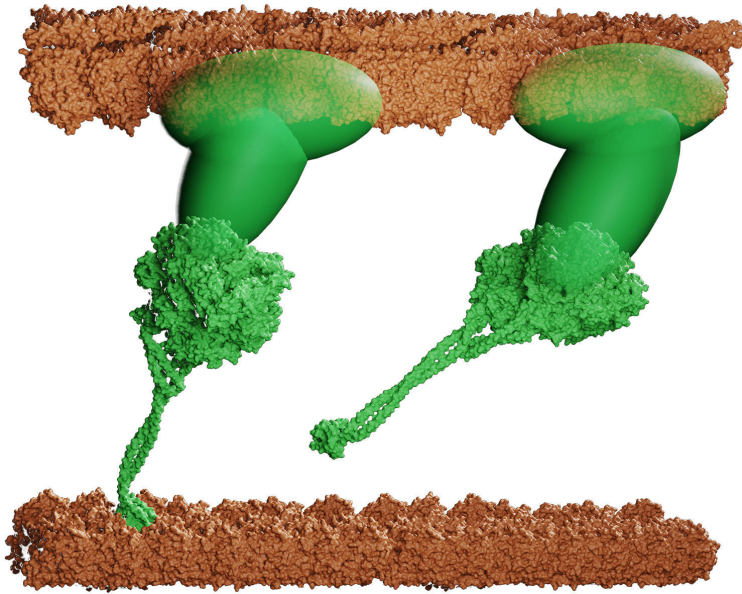


Figure 11.1: *Simplified representation of a motor molecule (Dynein), attached to two filaments (NB.: the conformation of the molecule is not accurately represented).*

molecules,” the network nonetheless represents something more than a transit system. Ranks of workers may indeed permanently be assigned to a particular location on the web, and use their mechanical strength not to move themselves or cargo on the road, but rather bend the road itself.

Working in unison, for a single purpose and in synchrony, a myriad of benders toil to adapt the skeleton of the cell to a continuously changing environment. Their little arms are flexed as they receive energy, pulling the thread on which they are attached in a particular direction, and thereby deforming the part of the cell to which this thread provides structural support (See Fig. 11.1). The most essential use of this faculty to bend the entire body of the cell certainly is to separate the two copies of the internal parts of the cell during replication and then cleave its outer wall, bending it around itself and seamlessly creating two spherical lipid ramparts from one, thereby marking the division of the old and birth of a new cell.

The unceasing flow of random mutations that occurs precisely

during the cell's replication leads to a continuous exploration of the possibilities offered by the network of filaments contracting and relaxing under the action of the molecular workers. Different configurations are tested, and many cells are snatched back by death as a result, but the experiments sometimes succeed, and new discoveries are made by life. One of such mutations caused some of the filaments to push the outer wall of the cell in a single location, creating a small appendix protruding from the rest of the spherical enclosure. This protuberance would soon appear to benefit the cell, in different possible ways, whose nature has yet to be elucidated. As it contracted and relaxed, it could have helped in repealing predators or gathering food, but as this innovation was passed on to the descendants of this pioneer cell and amplified, it soon also revealed itself as a means for life to stand up against the forces of nature that carry the cell according to their whim.

Selected for its size, flexibility, and the efficiency of its movement, the appendix soon turns into an elongated tail. Its inner structure becomes more complex, formed of a bundle of filaments arrayed in a circle, and on each one of them a battalion of workers toils to create a fluid motion. It works like a muscle, only on a different scale, as muscles are made of tissue, large assemblies of cells, whereas here the tail is part of a single unit of life. Its movement is nonetheless more complex than the mere flexing of a limb. The myriad of discontinuous flexing movements offered by each molecular worker must first be coordinated and transformed into a continuous wave, and this is done thanks to the circular arrangement of the bundle of filaments. The workers on each filament on the circle are activated according to a circular wave, and this alternation allows the generation of a wave-like motion of the entire tail.

Plunged in water, the movement of the tail causes the entire cell to spin. The living thing thus drills into the liquid, for the first time able to direct itself within the space opened up by the sea. By extending the reach of its working molecules, which are now driving the cell itself through its environment, the living thing breaks another chain binding it to the forces of nature. It ceases to be a mere piece of driftwood, carried by the winds of the sky and the currents of the sea. It is no longer a perfectly submissive slave to the moon, which controlled where it would go, through the pull it exerts on the sea, nor a captive of the sun, which stirs up



Figure 11.2: *A motile cell.*

the winds and currents by its heat. Even without a mind, without an ability to reflect and decide for itself, the cell benefits from the intelligence of the whole of life, which works through the two pillars which are mutation and selection, affinity and strife. Life itself can shape the behavior of individual cells, causing them to resist or accompany the flow of nature, as it sees fit.

Life therefore increases its own mobility, which has now been extended beyond the boundaries of the outer wall of individual cells. These units of life are no longer passively carried, and the com-motion that until now only reigned within their skin is now extended to their whole body, which agitates itself as it begins to explore the opportunities and dangers of its new ability. This com-motion also finds itself extended to the whole of life, the sum of all the living beings, as its giant mass now not only displaces itself by giving birth to new living things, or being passively carried by the forces of nature, but also through the motion of all the individuals composing it, accelerating its conquest of new parts of the seas and shores.

The emergence of the motile cell gives a new impetus to life. The edge that it provides in the battle for resources and survival causes it to multiply in great numbers, and this multitude of descendants can then move on its own, which each cell going its own way, exploring the depths of the sea, visiting the four corners of the earth. The drilling motion of the tail allows it to penetrate the

muddy soil to hide or eat and then go out of it if needed. It can now, theoretically at least, evade predators or chase prey. With the passing of each generation, only the fittest survive and reproduce, thereby leading to a continuous refining of its propulsion mechanism. The tail's movement progressively becomes perfectly adapted to the watery environment of the sea, its density and viscosity, whereas it would be useless on land or in the air. Since a great amount of energy is spent by this swimming of the cell, the triggering of its movement is also the subject of a severe selection. Through chemical signals, the movement of the cell can be regulated and linked with peculiar events, such as the presence of danger or the need to find a new food source.

Motility offers a huge benefit to life. It no longer needs to sow its seeds widely and indiscriminately in order to discover and conquer new fertile grounds, a process by which all the seeds that do not fall on good soil are condemned to die. These seeds of life can now by themselves search for more fertile ground, if they find themselves on an inhospitable one, thereby considerably reducing the cost of new discoveries in terms of lives, resources, and energy.

Empowered by its newly formed limb, the cell can go where no living thing has gone before, the blind spots where the currents do not carry anything and that demand an active struggle in order to be reached. These small beings nonetheless also rediscover what had been their environment all along, as they can now move through it, instead of simply floating in it. They have neither a brain nor memory, but through their sheer number and the power of selection, they collectively learn to navigate the seas, avoiding its pitfalls and taking advantage of their newfound skill. They no longer wait for food to come to them, but seek it, chase it, and even hunt and kill it. The cell could already sense the presence of potential food as it entered into contact with its outer wall, through the activation of rudimentary sensor molecules on its surface, which triggered the deformation of the wall and the engulfing of the food. Now, these primitive sensations slowly become coupled with the movements of the tail, as life discovers the correlation between the satisfaction of the need for food or safety and the beating of the appendix. This leads to the formation of a positive feedback loop between the sensory receptors and the tail. A sort of "intelligence" therefore already arises, in the sense of an ability to establish correlations and associations, long before the

emergence of a true nervous system.

With the passing of countless generations and the sacrifice of myriads of individuals, the motile cell therefore learns to appropriate the waters and the seafloor. It also learns that the presence of other living things, belonging to the same branch of the tree of life or more distant cousins, may either be a source of safety or danger. In the first case, an affinity will develop between them: the living things will be selected for their ability to use their motility to stay close, forming a huddle that could protect the whole that they form, either from the wrath of the earth and the sky, or from the hunger or rage of other parts of life. In the other case, a strife will be kindled, and those that succeed in aptly using their tail to swiftly evade danger will survive whereas others will perish, and the descendants of the former will therefore naturally outnumber those of the latter. In both cases, greater harmony will be found between life and the sea that it inhabits.

The cell has experienced a fundamental transformation of its nature. It is no longer a sphere carried by the forces of nature, but a living thing that moves, with an orientation, a front toward which it comes and a back from which it goes away. The spherical cell exhibited a symmetry in each of the three planes forming the space opened up by the sky and filled with earthly matter. It knows no up and down, front or back, and continuously tumbles, passing through time like a marble released on a slanted track, but unable to move itself through space. The motile cell, on the other hand, is no longer a sphere. It has broken the symmetry of its body across one of the three planes, and its existence is now tied to an orientation. It not only goes forward through time but also through space, as the two become tied to each other, because of their linear nature. The new cell can indeed only advance in one direction, forward, both through time and space. Its spherical, front-facing “head” represents its present and future, while its tail pushes away the past that the cell leaves behind. No matter how sinuous its trajectory is, the life of this being follows a line through space, as it does through time, one that is not the result of the whim of the earth and the sky, the currents and the winds, but rather the result of its own impulse, not guided by its non-existent intellect but by the sheer power of an instinct shaped through natural selection.

For us, humans, the ability of living things to move by themselves certainly is the most conspicuous distinction between life and death, the middle realm and the earth and the sky that surround it, above and below. But even before the advent of the motile cell, life has been associated with movements of the inner parts of the cell, and in particular, the spark that kindled the fire of life as a whole: the ability of the long chain of bases to self-replicate. This ability makes life appear as standing out from the realm of death: the earth and the sky, all the matter not animated by its fire. The animation of life is indeed so peculiar, as an uninterrupted chain reaction that has propagated itself through most of the history of our planet, that we feel compelled to consider it as “un-natural”, as standing out from the rest of nature, and yet, we should also not delude ourselves by failing to recognize the fact that standing out does not imply a severance. On the contrary, as something standing out from the rest of nature, from death, the earth and the sky, the tree of life rests and is deeply rooted in them. Life is not “super-natural”, even though it can oppose the flow of the rest of nature. Living things can move against the currents, but the source of their motility is profoundly natural. The remarkable machinery allowing these movements is neither “super-natural” nor “extra-terrestrial.” The chain reaction at the source of the fire of life and the balancing of its flames can be perfectly explained by the simple rules of the play of attraction and repulsion between atoms and particles. The recognition of this fact does not imply a denial of the super-natural, of a divine hand having shaped or continuing to guide nature, but it shows that the wondrous and perplexing beauty of life exists because of the perfection of the structure of nature, the laws ruling the earth and the sky, that is, space, time, and matter.

The movements of the self-replicating chain and the undulations of the tail of the cell are nothing but an exceptionally particular and complex case of the natural motion of earthly matter. Life stands out of nature, but it remains part of it, and the movements of the living share, on a fundamental, physical level, the same nature as those of the dead: the flowing river, the burning sun, or the breeze caressing our skin.

Re-flection: The Motion Within Us

The flow of the skies and all that they contain follows the path of the play of attraction and repulsion, as particles are continuously brought together and torn apart by the mysterious forces ruling the creation. The tumult of the earth and the skies, as well as the one of life, is a large scale manifestation of this play, with the accumulation of infinitely small movements shaping stars, planets, mountain ranges, and living things.

The fire of life nonetheless represents a unique phenomenon, appearing to stand out from the flow of nature, as it seems to enchant the earth, to bewitch matter, which under its power behaves differently than the dead. The chain of bases defining our body replicates itself with a ballet of molecules binding themselves together, expressing affinities that are directed and predicted by the rules of the play of attraction and repulsion. The complexity and beauty of this event nonetheless puzzle our mind and invite us to ponder its uniqueness, as the bits of earth consumed by the fire of life behave so differently than the rest of the realm of death.

The whole of nature is a gigantic tornado of earthly matter carried through the inscrutable depths of the skies, with each particle representing a pawn of the great game, whose rules are etched in the very fabric of the heavens. Enraptured by the fire of life, each part of our body nonetheless moves differently compared to what is dead. We are not merely pushed and pulled around the face of the earth by forces of nature overwhelming us. The power of the fire burning within us allows us to take action, to resist, and to move throughout space.

Only some branches of the tree of life have been endowed with the ability to move their body through water or air, but we belong to one of them, as one of our distant ancestors discovered a way to extend the reach of its workers. The boundaries of the cell were distended to form a tail where the molecular servants could do their work, moving through the action of energetic molecules, the limbs of workers pulsating as they are consumed, transforming reactions into movement through the fluid enfolding the cell, pushing its body throughout the sea.

The remnants of this discovery live in one of the most critical parts of our branch of the tree of life, as the male seed-cells use

this antique means of moving themselves to reach the female egg when love and life are made. As the life-giving fluid leaves or enters us, a multitude of cells frenetically beat their minuscule tails, instinctively traveling to reach their destiny, striving against their peers in the name of love.

Relaxing all our muscles as we float in the sea, we may experience the life of the beings deprived of limbs. We feel the current carrying us away as the waves push us up and down, while the breeze robs us of our warmth. The bliss of passivity, of inaction, calms our anxieties and soothes our heart as we contemplate the clouds above, and listening to the song of nature, we realize that this quietude can only be transient, or we would die soon.

As we start moving our arms and our legs, myriads of molecular servants of our cells set us into motion. Each one of them uses our stores of energy to frantically change their structure and contract muscles. Then do we notice our own power, as we can now decide where we will go, swimming against the currents and the winds. We can reach the safety of the shore or try to catch fish and mollusks that would sustain the fire in us.

Our destiny is now partly in our own hands, as we experience the freedom of swimming in the depths of the sea, with the three dimensions of this space all in the reach of our arms and legs, waiting to be explored. Swimming through water, our body takes a similar posture as the one of the first of our mobile forefathers. Our limbs become our tail, while our head and torso face forward, our horizontal body traces a line in the sea.

Our tail-beating ancestors broke the spherical symmetry of their bodies, acquiring an orientation, a direction. They, like us, used their limbs to rush toward what they desired and flee away from the threats to their being. The limbs bring us closer to what we love and far away from the forces striving to undermine our life, thereby empowering our kind and rendering us more capable of standing up to the wrath of the earth, life, and the sky.

Chapter 12

Love and Division: Choanoflagellates and Sexual Reproduction

The first spark of life was kindled when a long chain of bases began to replicate itself, as the earth was still young. Then, these chains became enclosed inside lipid walls, forming the first cells, and soon, these cells discovered ways of dividing themselves, as a whole, forming almost exact copies of each one of their parts. This process was refined, with an astronomical number of generations and individuals being sacrificed to do so. The cells, endowed with a core containing their library of information, our direct but extremely distant ancestors, thus elaborated an elegant mechanism to reproduce this collection and cleave it in two. These pioneers also developed a collar surrounding the basis of their tail, whose purpose is not entirely clear, because of which they received the name of *choanoflagellates*, “funnel-whip.”¹

The replication of the cell is an event that involves its entire machinery, its entire workforce, with each part carefully selected by life for its ability to perform the complex choreography of this miraculous display, the birth of a new life. This festival of life represents the high-point of the cell’s existence, its *raison d’être*, showing that the edification of a lifeform not only requires

¹From the Greek χοάνη (“funnel”) and the Latin *flagellum* (“whip”).

a painstaking work of exploration of the different structures that life can potentially form, that is, what physical arrangements of matter can open up new possibilities for it, but also an industrious scrutiny of the different sequences in which the elements forming these structures can take part, how these structures behave with the passing of time. Lifeforms cannot be reduced to a snapshot, an instant picture reflecting their nature at a particular instant, as they experience important changes during their existence and pass through different stages, which are sometimes part of a cycle that will be repeated until the fire of life has consumed all their forces.

The festival of the birthing of a new cell, the choreography which ends with the cell's division, is part of this life cycle. It will be repeated until the cell has exhausted its capacity to replicate, until its parts are too decayed to perform this sacred ritual, passing on the torch of the celebration of life to its offspring, a celebration that has probably not been significantly changed between its first performance and the present day. This ritual begins with the laborious weaving of a new copy of the library of information at the center of the cell. The chaotically tangled chains are then ordered into stacks, better known under their technical name of *chromosomes*, as the hierarchy of the cell is dissolved. As the content of the library has been carefully reproduced by the scribe molecules, and attentively packaged into bundles that would be less prone to be damaged, the walls separating the holy of holies and the library from the rest of the city are taken down by its servants. Without their protective enclosure, the bundles of precious information of the library are scattered throughout the city, but they are swiftly taken care of, arranged to form a line at the center of the city, as if they were to be exposed for all to behold them.

The ceremony has begun. On the opposite sides of the city, the workers controlling the web of filaments forming the roads of the city received a signal, and they begin to play their part, promptly extending new filaments in direction of the precious stacks, arrayed at the center. From both extremities of the city, opposite to the line formed by the stacks forming the library and its facsimile, the filaments are like slender arms or fingers, protruding out the facilities producing them, searching for the inestimable books in which all the discoveries made by life are safeguarded (See Fig. 12.1). Patiently weaved with threads of molecules by skilled chem-

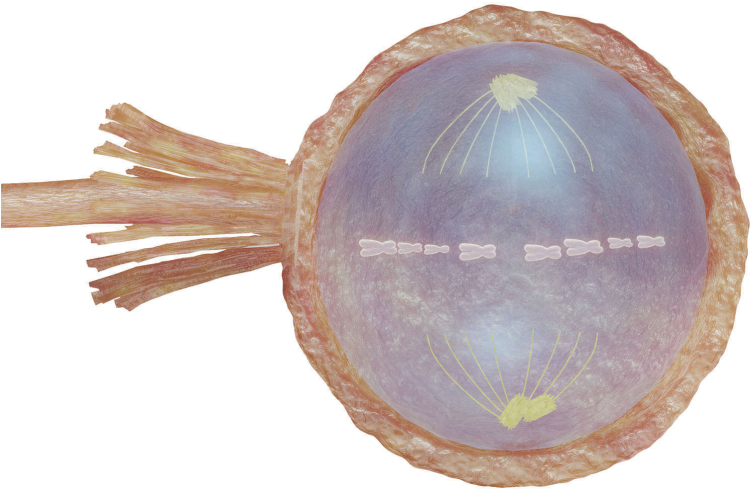


Figure 12.1: *Division of a cell (1).*

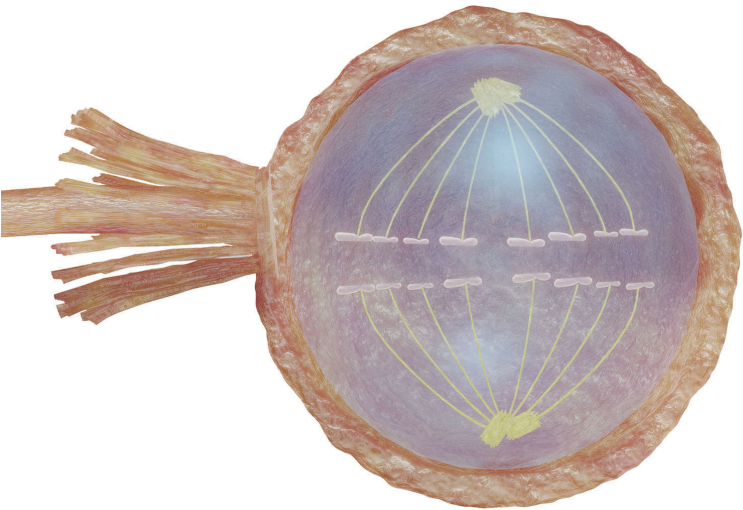


Figure 12.2: *Division of a cell (2).*

ical artisans, the slender arms soon find what they sought. From both sides of the city, the fingers at the end of these arms take hold of the center part of the stacks, which are so arrayed so as to welcome each one of them. Each stack is pierced in its center by these fingers, without damaging their content, as their movements are both gentle and precise. The fingers of both arms seizing a particular stack meet each other at the center, which is also the joint where both the original stack and its duplicate are attached to each other, forming a shape similar to an “X.” As the fingers of these two molecular hands are wrapped around each side of this central junction, a new act of the sacred ceremony of life begins to unfold. A signal is received, and the two commanders of the arms initiate their retraction. They are progressively shortened, pulled toward their origin, as the threads of molecules forming the filaments are loosened, disentangled, and decomposed on the other extremity. This occurs while the fingers are still tightly holding on to the two copies of each stack, and as the pull on the arms slowly increases, comes a breaking point: the bond joining them is now torn apart. The original and the duplicate stacks are both pulled toward a different side of the city, slowly parting with one another. The city already begins to lose its unity, as not only has its central core been dissolved and its library of information been scattered, but there are now two distinct copies of the library, found on opposite sides of the city (See Fig. 12.2). Both sides are still enclosed by a single wall, but the city is already cleaved into two, relatively independent parts.

The second act of the ceremony then begins. The period during which walls and barriers separated the elite of the city from its humbler inhabitants and workforce abruptly comes to an end. These barriers have been torn down, marking a time of apparent equality, with all sharing the same threats, such as the chemical beasts roaming throughout the city. In each one of the two halves of the city, the stacks forming the content of the library are brought together in a central location. Around these two temples of knowledge of life, the two-layered wall is then hastily rebuilt, once again protecting and separating this holy of holies from the rest of the city. The hierarchy is restored, but the city is now divided into two independent communities. The entire machinery of the cell has been replicated and can now be found on each side of the walled domain. A relative calm now reigns within the wall, but

behind this veil of tranquility, couriers dispatch orders all around the city, and messages are sent and received. Once the two sides are ready, having severed the last bonds uniting their inner parts, the final part of the ceremony can begin.

For the third and final act, the dense network of filaments pervading the city is once again set into motion. Among the innumerable threads that are deeply inserted into the outer wall, those present on the central part, delimiting the boundary between the two communities sheltered by the wall, are shortened, according to a precise pattern, carefully selected through generations and generations. Like puppeteers, the parts of the cell controlling this web of threads begin to reshape the protective rampart that allows the fire of life to burn inside it without being quenched by the watery currents and the host of threats that they carry. It is bent upon itself at its center, as the tail and the collar now surrounding it, which allow the city to navigate throughout the sea, are cleaved in two, as invisible workers busy themselves to repair this seemingly damaged structure, which slowly finds itself transformed into two independent and complete sets of tails and collars (See Fig. 12.3). The boundary between the two sides of the spherical city is now a circle that grows increasingly smaller, as the puppeteers continue their work and pull their threads. Once the circle has been reduced to a point, the two sections of the lipid wall, the ranks of guards forming the rampart protecting the city's inhabitants, break their rank and let each other go, now forming separate walls, guarding separate cities. The choreography of the ceremony, perfectly executed after a multitude of trials and refinements, is now complete. The cell has given birth to another, through a prodigious performance that has involved its entire machinery.

This ritual is still one of the major ways by which the fire of life is propagated, through the replication and division of a single cell. The relentless exploration of all the possibilities offered to life nonetheless continued. Another ceremony was developed by the cell, after numerous experiments, many of which probably led to the premature death of those performing it. So beneficial to the lifeforms it involved, this new play would soon become a central, if not the central event of the lives of the members of most branches of the tree of life, including the one to which we all belong. Even the mere utterance of the name of this new celebration of life is not without effect on most human beings: sex. Its origin is still



Figure 12.3: *Division of a cell (3).*

largely shrouded in mystery, but the knowledge of the nature and effects of sex in currently living species can nonetheless help us get a picture of how it arose.

It appears that sex came to be as the result of a pressure exerted upon particular living beings, such as the motile cell examined in the previous chapter. Present-day single-celled organisms are known to switch between the aforementioned mode of reproduction, called *mitosis*, and sexual reproduction when they are subjected to different types of pressures. One of them is the presence of a certain density of bacteria in their vicinity, and another is the lack of nutrients.² Other hypotheses have been proposed, such as the fact that the emergence of sex may have occurred as a reaction to the damage caused by the chemical beasts released by the light-workers, that is, oxygen, upon the library of information of the cell, as sex indeed leads to a reduplication of the library, with two copies of it stored on the same location during most of the cell's life, which is used to correct any mistake of the molecular scribes. The exact nature of this pressure, this trigger for the

²For more information, see: Ieng Fong Sou, et al. "Meiosis initiation: a story of two sexes in all creatures great and small". *Biochemical Journal*, vol. 478, no. 20, Oct. 2021, pp. 3791–805

emergence of sex, is nonetheless not as important as the effect that it had on the growth of the tree of life, and this effect on one of our direct ancestors is what will now be examined.

As briefly mentioned earlier, the motile cell has now developed a collar, composed of small ribbons, whose exact purpose is not entirely clear. At the time of its emergence, it represents one of the most advanced specimens of life and yet, it suddenly found itself threatened with extinction. The nature of this threat remains in the shadows, but its effect is clear: many members of the population of collared cells are at this point unable to properly perform the ceremony marking the birth of a new life. The library at the center of the city-cell is under attack. As three ranks of guards are protecting this holy of holies of life, the outer wall and the two inner walls of the core, the menace is probably not limited to a frontal attack by a chemical. Another, more insidious danger may nonetheless imperil the city, one that has led entire species into the abyss of death, from the humblest creature unto entire empires built with the lives of men: starvation.

Life is the child of earth and sky, and even though it grows increasingly independent from their care, it will forever need them for food and energy. Furthermore, the collared cell also itself depends on “lower” forms of life, those harvesting the power of the sun in particular. Even with armies of skilled artisans inside themselves, these cells cannot manufacture all the materials that their city/body needs. They need to bring them from the outside, either re-using the ruins of other, decayed cities, or engulfing living ones, destroying them for resources. There may nonetheless come times when the supply of materials may be insufficient to sustain a whole group of cells, which would then be forced to compete for survival. If the library contains no free bases, which are the ink and letters used to inscribe the precious knowledge of life, and the blueprints of the city’s machinery, the scribes working in it are then left unable to perform their duty. Without their ink and paper, the copyists cannot properly do their work. Either the replication of the library is stopped, or the scribes only provide incomplete or corrupted copies. Such corruption may also be caused by the attacks of foreign substances or a noxious environment, but whatever the cause may be, the result is the same: the ritual leading to the birth of a new cell cannot be performed as it should.

As the ritual involves a reorganization of the entire city, its interruption can be catastrophic, not only leading to a failure to give birth to a new life into the world, but also to a collapse of the entire city. Like a piece of colossal machinery in which a massive wheel would fail and take the entire structure down due to its inertia and its considerable weight, the disruption of the replication of the library is an event hard to recover from. Many city-cells are therefore brought to ruins because of this new, shadowy threat. Their numbers quickly dwindle and, if they do not promptly react, their entire branch may wither and fall from the tree of life. Fortunately, life's greatest asset, the cell's capacity to mutate, allows it to explore new options. The exact course taken has yet to be (re)discovered, but it may have begun with a single cell inheriting a scribal error in its library, one that would lead its own scribes to make two sets of duplicated stacks instead of one. Instead of one series of cross-shaped duplicates, bundled together at their center-point so that they can be seized and separated during the ritual of the division, the library now contains two of them, that is, four copies of all the information, organized as two sets of bundles. This scribal error would soon trigger a cascade of transformations that would ultimately help the city overcome the shadowy threat, and cause its offspring to displace its relatives.

It without a doubt took a considerable number of attempts and further mutations, but one day, one of the children of the cell endowed with two sets of copies of the library developed a new ceremony, one that would take full advantage of its peculiarity. This new, slightly more complex ritual, nonetheless is in most part inspired by the one created by the ancestors of this cell. It begins similarly, with the rearrangement of the information of the library into dense, cross-shaped bundles³, composed of two (normally) identical copies of a part of the library,⁴ but here does a key innovation appear. A play of affinity and strife is set into motion between the two bundles. The long chains of bases are broken in different parts, leaving gaps in them, and these gaps lure parts of the chain of the other bundle, seizing them like one embraces a lover, but like a praying mantis decapitating its mate, once the pairing has been completed, the parts that were ensnared by one chain are cut off from the one to which they originally belonged,

³In technical terms, *Chromosomes*.

⁴Two sister *chromatids*.

thereby shuffling the sequence of bases of the two bundles.⁵ Servants of the library quickly mend the wound on the damaged chain, while this play is unfolded in each one of the bundles. This leads to a radical transformation, as each one of the four copies of the library therefore now becomes unique, with none of them faithfully reproducing the original content of the information passed on from generation to generation by countless of their ancestors, from the very beginning of life. This transformation nonetheless remains very limited. Most of the information is still present, only rearranged, with slight changes of meaning, keeping an equilibrium between the need to innovate and the necessity of relative stability.

After this peculiar event, the new ceremony continues, mimicking the traditional one. The bundles are moved on the equator of the spherical city. In this ceremony, there is nonetheless twice the amount of information as before, and as the slender arms made of filaments come to separate the content of the library, they each seize one entire bundle, containing two copies of a particular part of the library, whereas a pair of arms tore apart a single bundle in the previous ritual. After this, the new ceremony resembles the more ancient one. The inestimable knowledge of life is once again gathered at the center of the two emerging communities on each side of the city, and their protective walls are rebuilt, before the outer wall is reshaped to separate these communities into two independent city-cells. A major difference can nonetheless be noticed: with the old ritual, a parent cell produced a daughter cell that, barring relatively rare random scribal errors, would contain a library of information that would be identical to the one of its close ancestors. Now, with this new ritual that includes a transformation of the long chain of information, a reshuffling of the content of the library, the parent disappears as a result of the ceremony, leaving in its stead two daughters that, even though they preserve most of the wisdom of their ancestors, are far from identical to them. Both are unique, and their identity is the product of the relatively random transformation of the library as much as of their parents. This, however, is only the beginning of this “revolution.”

As the daughter cells now each contain a set of cross-shaped bundles containing two copies of the library, they find themselves in

⁵This event is known as *synapsis*, and the shuffling of the information as *recombination*.

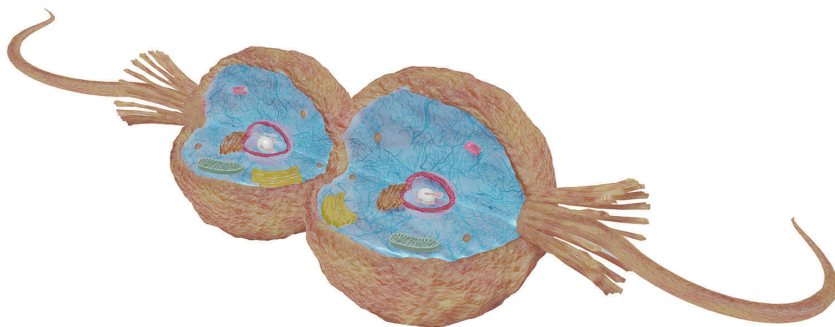


Figure 12.4: *The fusion of two cells.*

a similar situation as a cell ready to perform the ancient ceremony, and this is precisely what they are going to do. The two daughter cells therefore give birth to four granddaughters, each having a unique library of information. The granddaughter cells do not have any copy of their unique library, and this renders them as vulnerable as their ancestors, the parents of the cell that discovered the advantage of a redundant library. A severe selection may once again have been undertaken at this point of the new ceremony, whose performance is spanned across generations. Some may have attempted to simply copy their own library, but life found a better way, a more secure path.

A community of cells performing this new ceremony would quickly give birth to a large number of granddaughter cells, each one of which would be afflicted by the plague that decimated their kind for generations and whose exact nature still eludes us. Fortunately, the adaptability of these granddaughters has been multiplied by the fact that each one of them represents a unique “experiment” of exploration of all the possibilities offered by life, the trial of a new genetic code that may unlock new secrets of life. Relying on its capacity to generate an abundant flow of new lives and select the pioneers that made discoveries useful to themselves and their kind rather than on any form of intelligence of individual creatures, which has yet to emerge, life tries new performances, until one day, when one of them was found to be particularly promising.

A couple of cells, still experiencing the pressure of the shadowy threat, encountered each other in the tumult of the sea. They felt the need to push themselves against one another, undulating their

tail with all their strength, drilling into each other with all their might (See Fig. 12.4). Relentless and obstinate, both soon reach their breaking point. The very structure of their head is weakened. Their outer wall begins to bend and break, nonetheless not leading to a general collapse. The two living beings are fusing into one, merging their outer walls into a single rampart, while the content of each one of them begins to infiltrate the other.

What may first have appeared as combat becomes sexual union. War turns into love. Each partner is incomplete, as its core, its heart, is in need of a complement to its library of information, another set of stacks that would allow it to face the shadowy threat and give birth to an offspring. United by their incompleteness, and fusing their bodies to become a single living being, they gather their essence, pool their resources. The cities are merging one into the other, from their wall to their innermost part, their holy of holies, an act that represents the pinnacle of the new ceremony. The two complementary libraries are gathered in a single location, remaining distinct but both accessible to the scribes serving this sacred place. Once a harmony has been found between the two communities, with the dismantling of redundant parts, a new life is born, one that bears in its heart the library of both its parents, exploiting their uniqueness when this may provide this child with an edge against its competitors and enemies. The ceremony has been completed, and life has discovered sexual reproduction, that is, reproduction through the union of the library of information of two parents.

The new ceremony, this new way to give birth to new lives, is both ingenious and beautiful. It will also prove itself to be a formidable tool helping many branches of the tree of life to overcome various threats and grow, higher and stronger than ever before. This new, elaborate ceremony will nonetheless not supersede the traditional one, but rather only complement it, at least for a while, in the branch examined here: the collared cells. The elegant and sophisticated ritual indeed also comes at a cost, which will often be too heavy to bear. Each living thing is still constantly forced to compete for resources with the other members of its kind, racing to out-breed its competitors, and the new ceremony leads to a halving of its birth rate. With the traditional ritual, a single parent produces two daughter cells with one round of division, whereas two rounds are needed to produce the same result with

the new one. Sex costs a living thing half its potential offspring, a rather hefty price.

Sex nonetheless provides important advantages that may offset its considerable cost. The children of love, born of the physical union of two parents, have two unique libraries, with each one of them containing the complete blueprint of a viable cell. If one is critically damaged, the scribes serving in the holy of holies can simply copy the information of the other, ensuring the proper functioning of the city-cell. If the cell were to find itself in a noxious environment, such as one bombarded by an unusually heavy rain of radiation, from the sun or other celestial bodies, strong enough to pierce through the cell and corrupt parts of the library, its ability to correct these corrupted parts would provide it with a crucial edge over those incapable of doing the same, and its descendants would soon reign supreme over their domain.

Another important advantage of sex is that it considerably enhances a living thing's capacity to adapt and evolve. The transformation of the library of information that occurs at the beginning of the ritual is far more extensive than the random scribal mistakes that drive the evolution of the living beings that reproduce through simple division. It is also less random, as the information is not arbitrarily changed, but often rather only cut and reorganized, producing new meaning using old content. It is a new book written with random paragraphs taken from others rather than random letters, thereby far more likely to result in a new meaningful content. These less random changes in the library of the cell would thus be less likely to produce children that would not be viable or able to reproduce. Furthermore, the power of this transformation is multiplied by the fact that each child of love inherits two unique versions of the library, with each one of them representing the exploration of one possible path that life could take, which may lead to an important discovery, which would help the tree of life to defend itself and grow.

Life, in its intelligence expressed at the level of whole populations rather than the one of individual beings, nonetheless not only discovered how to use sex to fend off threats and evolve more quickly, it also learned when to use it and when to abstain from using it. The collared cells, among others, have been selected by nature for their ability to evaluate when the advantages of sex

would outweigh its cost, and to choose which ceremony to perform accordingly. When the times are hard and the cell faces an existential threat, its offspring will have better chances of surviving and reproducing if they are more resistant, even if there is only half the number that there would be using the more ancient way of reproducing itself. On the other hand, when the times of plenty comes, and the competition with its brethren is a race for outbreeding rather than a fight for resources, the cost of sex can no longer be justified, and the cell thus reverts to the ancient way, thereby doubling its potential number of descendants. Carefully selected for their switching skill, the cells appear endowed with real intelligence, even though they by themselves know nothing.

There is therefore a time for love and a time for division, a time for union and one for separation. Sex embraces both love and division, uniting them both while the two partners taking part in it merge their bodies, as its ritual begins with the cleaving of its parents, giving birth to the cells that will crave their complementary part, the partner with which they will mingle their most intimate essence, the knowledge defining their being concealed deep inside their heart, once their flesh will have fused. Sex is division followed by love, whereas the ancient way is simply division.

The time for love between the cells nonetheless comes when war rages around living things. It is when they are attacked, their very existence threatened of annihilation, that the collared cells begin the ceremony of love, which will give them strength to resist and live, perpetuating their kind and passing on the wisdom of their ancestors to new generations. This war may be waged by other parts of life itself, but also by the parents of the middle realm as a whole: the earth and the sky. The tumult of the kingdoms above and below always represents a challenge to life, which has been shaped by them through the ages and whose capacity to react takes entire generations to be set into motion. If the earth experiences radical changes in a short lapse of time, it may no longer provide a viable environment for particular forms of life, which will find themselves under extraordinary pressure to adapt. The way of love, sexual reproduction, may then help them prevail against this new, hostile environment, driving a rapid evolution through change and selection, and the birth of a smaller number of children, but children endowed with a higher adaptability. Their population would grow more slowly, but stronger, more prepared

to face instabilities leading to lacks of resources or even direct aggression.

The time for division, on the other hand, paradoxically comes when peace reigns among life. Love is war, and peace is division. It may, for example, come when the earth and the sky provide a very stable environment for life, providing for its every need without exerting any pressure on it. Living things would then be able to reproduce in large numbers quickly, through division, but in the absence of war, they would have no incentive to make new discoveries, and the selection of the fittest individuals would be minimal. For life, peace and stability therefore imply stagnation, a considerably reduced rate of evolution. It indeed needs war, either civil strife between branches of the tree of life or one with the larger forces of nature that form its environment, such as the earth and the sky. Without love, without war, life therefore loses its main driving force, and its salt.

The transformation brought on by the advent of sex is nonetheless not limited to individuals. It profoundly changes the relationship and interactions shaping entire branches of life. During times when division reigns, “bloodlines” are entirely vertical, with individuals only related to their single ascendant and descendants, lone parent and children. Many cousins and more distant relatives may abound in their vicinity, but the living things do not need to interact with them and have no reason to do so. Each one of them can depart far away from any other member of his kind, and it will still be able to fulfill the mission inscribed in its core, carefully selected by life to ensure its prosperity: live and reproduce. It can reproduce in solitude and has little to learn from others, and this for a very simple reason: all its relatives are clones of itself. Excluding relatively rare scribal mistakes during the replication of the library of information, close relatives all share an identical repository of knowledge, and an identical body, which is built from it.

When the time of war comes, and the living things begin to perform the ritual of love, the relationship between the members of the same kind is then profoundly altered. Each individual now possesses a unique library of information, and therefore also a unique body. The degree of relatedness that it shares with its parent(s) is lessened and diluted as it now possesses two ascendants rather

than one. The vertical bond is weakened, but another will be created. During the middle part of the ceremony, when each parent gives birth to a couple of “incomplete” children,⁶ that will take part in the act of love, comes the occasion for a bond to be weaved between the members of a kind. Each incomplete child soon craves for a union of its flesh with the one of a partner. This partner could be its sibling, the being born together with it, during the same division event, but it can also choose another, more distantly related partner, that would be chosen from all the members of its kind with which it could enter into contact, whether it may be close by or very distant. A horizontal bond can thus be knit between all the members of a kind, as they unite their flesh and give birth to an offspring that will combine the essence of them both, thereby increasing the variety of this branch of the tree of life and its ability to adapt to an ever-changing world. Because of this advantage, communities will begin to be formed, as individuals will benefit from the presence of a large pool of potential partners with whom to mate. They will cease to seek solitary lives, and stay in a group, stronger together than they ever were before.

The consequences of the advent of sex nonetheless also reach another dimension. The effects of sex ripple through time and it soon triggers a cascade of subsequent transformations of life. One of the most important ones arises during the performance of a particular part of the new ritual, when the incomplete cells are seeking a partner. The finding of a mate probably began as the result of random encounters, with the fusion systematically occurring with the first potential partner that was stumbled upon. As generations upon generations perform the new life-giving ceremony, the situation nonetheless gradually evolves. Some cells perform better than others, and their offspring begin to outnumber those of the less performant ones. Equipped with primitive sensors on their outer wall, some of them begin to discriminate potential partners, as they were themselves selected for their ability to distinguish partners who would produce superior children. Those who did not develop such skills were simply outnumbered by those who did, and their kind withered into oblivion. This marked the beginning of an arms race between the cells searching for a mate, with only the ones producing the fittest descendants being able to successfully find a partner.

⁶They are known as *gametes*.

The arms race would in turn also lead to the emergence of a differentiation between the incomplete cells. As if both partners stood over on the summit of a mountain and were then blown by the winds on two different sides of it, forced to part ways, two potential kinds of partners began to emerge. The reason for this may become clearer with an example, which may not reflect the exact origin of this differentiation, which is largely unknown, but is nonetheless plausible. Just like two different kinds of living beings may specialize themselves and thereby better serve each other, as it was the case between the host cell and its guest examined in a previous chapter, the incomplete cells may become better partners by developing different, complementary characteristics, instead of being identical. It would be easier for a small, vigorous cell to penetrate the body of its mate, than for two similarly sized ones to fuse, as their outer walls would sustain less damage and be more easily repaired. Conversely, a larger cell would be less motile, less prone to actively find a mate, but its more stationary nature may render it more easily found, and more easily invaded. By diverging from each other, the two types of complementary cells can develop qualities that would benefit their children but be contradictory, canceling each other if they were to be found on a single living thing. One must choose between being fast or being large, as the presence of one quality constrains the development of the other. Life nonetheless once again proved its ingenuity, by solving this conundrum: one cell will be fast, and its mate will be large. This dichotomy between the two types of cells would eventually lead to an exclusivity, with mating only possible between complementary types, and this would mark the birth of what is known to us as the difference between males and females. Even though the exact nature of the pressure that led to their differentiation is unknown, the aforementioned collared cells do exhibit a contrast between mates, with one type, usually considered the male, smaller than the other, considered female, even though the use of these labels for single-celled life is rather arbitrary.

With the advent of love therefore also comes the beginning of a war of the sexes. Males compete to be fast, strong, and able to detect females, to find a mate and father children, while the females are selected for their ability to discriminate male partners, while they wait for suitors to come to them. This new layer of selection would prove itself particularly efficient, and provide a

new impetus for the evolution of their kind. Striving between the other members of their gender to find their loved one, they improve themselves and thereby fortify their branch of the tree of life. The war for love and the love of war nonetheless only begins.

Re-flection: The Love Within Us

The fire of life has burned without a single instant of interruption through the ages, for it draws within itself the source of its own rejuvenation and evolution. Following the loving encounter of our parents, when they mingled their seeds to conceive us, the resulting cell repeatedly divided itself during the better part of a year inside the motherly womb. Our body progressively took the shape of an infant as the number of its cells grew, and once our senses emerged and were refined, we were thrown into the world, coming to being.

The division of countless cells, part of our body, continues at this very moment. They perform the antique ceremony where their library of information is meticulously duplicated, and their entire machinery is reproduced almost identically, turning the food we ingest into new parts of life. Hairs or nails, whose recent regrowth we now notice, are the most conspicuous of those, the most recent additions to our body, fruits of the patient work of division of older cells, with every single one of them being the direct descendants of the seed created by our parents.

Watching how our body has now matured and conscious of the endurance of the ritual of division in us, we may now picture a person we love and desire, awakening our most deeply entrenched instincts. Letting ourselves be allured by the beauty of the flesh or succumbing to a charming nature, we let our senses take hold of our mind, feeling the attraction inviting us to embrace the other.

What we experience, the sensation of lust pushing us to merge our body with another, or the feeling of love urging us to let our own self be dissolved with the one of our beloved, it is the essence of the living fire calling us to perform the sacred ritual of love and life. This lust of the flesh, love of the mind, is what drives the propagation of the fire, and this is how our own being can transcend our inevitable death, by creating new life.

Life itself has shaped our mind and our world to let us know who is desirable and who is unfit. What we lust for is what will benefit our descendants and the whole of the tree of life. The merciless selection we operate ensures the health of life and its growth, as the strife between men and women for the best partners is a prerequisite for the act of love. The love of war is kindled by

the war for love, and the blood spilled waters the tree of life.

The play of attraction and repulsion, love and war, is constantly unfolded under our eyes, and consciously or not, enthusiastically or not, we all play our part on the stage of nature. The attraction we experience when faced with a desirable person deeply shapes our behavior, as our flesh feels drawn to it, while our mind yields to the desires of our loins, extraordinary efforts must be deployed to resist this call of nature, and few want to do so.

When we imagine our hands sensuously embracing the naked, enticing body of a beloved, our skin is pressed against it, feeling the fire burning inside it while kissing passionately, we may remember that this is a prelude to the sacred ritual leading to the creation of a new life. As one body enters the other, joining the most sensitive and intimate parts of the two bodies, the pleasure that is felt is the reward of life for the performance of our sacred duty.

The climax of this prelude occurs when the man releases his essence inside the woman, but the end of his role marks the beginning of a new strife for life, a new play of love and war. Following the strife for a lover, the countless seeds of the male must now also compete, as they race against one another, with only one of them allowed to unite itself with the egg. The minute and the gigantic find themselves mirrored, with strife pervading all layers of life.

As the lovers rest from their passionate dance, the war of the seeds only begins, and when a champion has been chosen by life, the sacred ritual can finally be performed. Inside the egg, a new unique library of information is composed of ours and of the one of our lover. The seed-cell of a new human being is then created, dwelling in the depths of the womb.

As we observe the people around us and let the image of our loved ones come to our mind, we may remember that each one of these human beings began as a lone single cell inside a womb. They all are the fruits of love and war, with their parents striving to seduce their partner, and as their bodies were united as they listened to their senses and their instincts, innumerable but incomplete seeds of the man desperately competed against their peers, with only a single one of them succeeding in finding its other half, merging with it.

All the men and women around us, and ourselves, embody

success and fitness to live. Our parents all found a suitable partner with whom they gave birth to a child. We all received half of our library of information through the agency of a fatherly seed, and this seed prevailed while millions of its peers failed, reaching the precious egg. Conscious of the efforts deployed to give us life, we may therefore strive to be worthy of their efforts.

Chapter 13

Strength in Numbers: Social cells

The emergence of sex on a particular branch of the tree of life leads to a considerable increase in the diversity of the individuals belonging to it. Before this event, children were largely clones of their single parent, with an evolution only significant after a very consequent number of generations. Now, however, the divergence goes on at an accelerated pace, fueled by the shuffling of the library of information that occurs during each life-giving act of love. Children significantly differ from both parents, but they differ even far more from their cousins and more distant relatives. On the one hand, the genetic bond between parent and child has been loosened, as each now possesses a unique “identity,” but because such a bond is even looser with more distantly related individuals, this induces the appearance of a gradation of relatedness, a progression of the kinship bond, which did not really exist before, when all the members of a group shared an almost identical library of genes. With a unique identity for each individual cell, comes familial bonds, kinship, which measure their proximity in the tree of life, their genealogy.

As the library of information of each individual becomes increasingly divergent from the one of its relative, the line between groups and branches of the tree of life begins to grow increasingly blurry. Each cell frequently comes into contact with its brethren and more or less distant cousins, but the uniqueness of each one

of them renders their identification far more difficult than before, when they were all almost identical. Who is a friend? Who is a foe? Who is a potential mate? Considerable pressure is then exerted on the individual cells, which must develop more finely tuned ways of identifying their own kin, which may be more enclined to cooperate with them, and ways of distinguishing them from the members of other groups, other species, which may be more likely to represent threats to their kind. A shared nature and kinship would indeed often imply the facing of the same challenges, and therefore common interests. They need the same food, a similar environment, and may therefore soon discover that, like a bundle of branches cannot be broken in half by man's hand whereas a single twig will, they may all benefit from uniting their strengths.

Sex already encouraged the collared cells to stay together, and avoid wandering alone in the vastness of the seas, as they need to find partners with whom to mate. They also are already equipped with a rudimentary sensory apparatus, receptors embedded in their outer wall, which activate chemical switches when they enter into contact with certain substances (See Fig. 13.1). These receptors, coupled with the machinery of the cell that secretes various compounds that are floating in the sea in their vicinity, allow the living thing to gain a certain (unconscious) awareness of its surroundings. As a blindfolded person can identify a family member by the perfume it wears every day, the cell can learn to identify its kin, by detecting a particular series of compounds that they secrete. Once again, the learning work is not performed by individual cells, but rather by life as a whole, through strife and selection. The cells that are unable to recognize friend from foe are reclaimed by death, like sheep incapable of identifying wolves, while the more astute and discerning ones, which through the random shuffling of information of their library acquired more discriminating receptors, fend off the threats, live, and give birth to equally perceptive children.

Cells therefore begin to develop social bonds with their neighbors. Groups are formed, according to special affinities, grounded in the spectrum of substances that they emit and receive, a series of chemical signatures that draw lines between kin and stranger, mate and enemy. The path to love is cleared by some molecules, while war is kindled by others. Infinitely small differences in the play of affinity and strife between atoms serve as sparks igniting

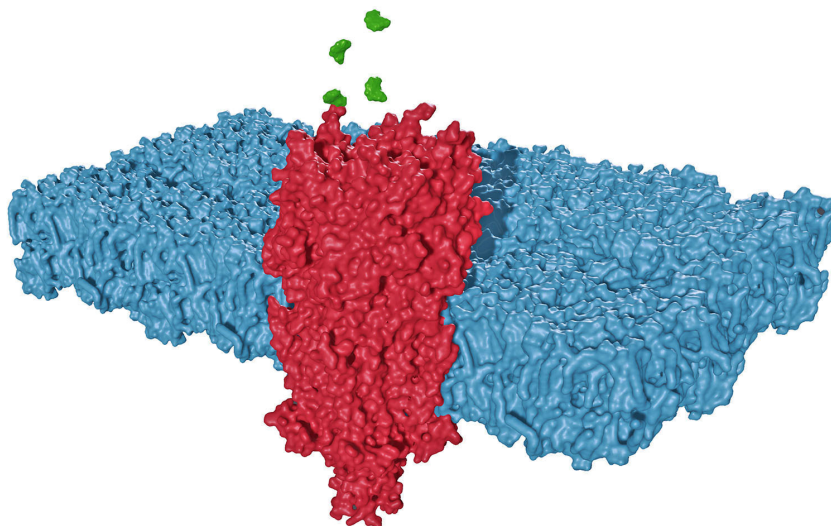


Figure 13.1: *A serotonin receptor (in red) inside a cell enclosure (in blue), receiving serotonin molecules (in green).*

conflicts on a far larger scale, between entire cells, and even large groups of individuals. The gap between groups and species widens as family ties emerge and grow tighter, ties not solely based on their sharing of a single library of information, the blueprint of their own flesh, but also on the development of agreements and bonds based on the emission of bits of information, encoded in the form of a unique arrangement of atoms, the product of a precise pattern of attraction and repulsion, through the intelligence emerging out of natural selection rather than out of the will of any particular living being.

The severe selection exerted on the cells endowed with a sensing apparatus then slowly but continually refines their kind. Affinities between receptors and substances grow in number and in strength, as the spectrum of what is perceived and what is broadcast widens. Series of patterns slowly emerge out of the randomness of the play between living things, increasing the polarization of the relationship between them. Increasingly intricate ties are woven with the loved ones, as tokens of love are exchanged between cells, tokens that take the form of substances shaped by the machinery of the cell itself, and rarely or never found in nature. They appear to represent something, to bear meaning, which

would be recognizable by both the one sending it and the one receiving it. One should nonetheless here be careful of the dual nature of anthropomorphism, which can help man shed light on nature by relating his own experience and his knowledge to the various processes at work in his world but can also veil the truth of nature by leading him to think of all things as if they were conscious beings like him. If forms of “meaning” arise during the exchanges between cells, it would not be because individual cells, sharper than others, would have one day decided to assign it to a particular substance, as they have no such power of decision. Meaning arose out of randomness, or perhaps fate, because it provided an edge to the cells whose libraries of information had been reorganized in such a way that they contained the blueprint of the token and a series of actions with which it would be associated.

The interactions between social cells exhibit some of the characteristics of language and communication. Messages are exchanged in the form of substances, and these messages can trigger cascades of reactions in the cell receiving them. When a male seeks to encounter a female belonging to his kind to mate and father an offspring, he can secrete special substances signaling his presence, his nature, and his intention to females found in his vicinity. A trail of such tokens may even be followed to locate a potential lover, like a series of road signs guiding a visitor. This apparent intelligence and communication is nonetheless a mirage, as not a single cell “knows” what it is doing and why. Out of the myriad of cells whose nature was randomly modified, only one may have been able to produce a message that would trigger a reaction in another single cell, but this one had an advantage, it discovered something new, something useful, and because of this its descendants grew more numerous. The cell did not create the message or the reception apparatus: it is the cell itself that was shaped by life and nature in order to be able to produce such messages or receive them, because it allowed its kind to flourish, increasing the likelihood of survival and reproduction of its members, their ability to repel or evade threats and to attract a mate, that is, be skilled actors of the play of love and war.

Cells do not learn during their lifetime. It is life as a whole that learns from their death. Those that withstand the assaults of the earth and the sky, and the onslaughts of other living things flourish while others perish. By infinitely small incremental steps,

each representing entire generations of beings, life learns. Each aggression is a blessing, and the greater the pressure is, the greater will the step that it climbs be. As long as life is not wiped out entirely, it will continue to gain the knowledge necessary to resist an increasingly wider range of threats, and the tree will extend its branches higher toward the sky.

Through the semblance of communication between cells brought on by the discovery of the sensory apparatus, individual cells can therefore begin to form a more closely-knit whole with other living things. It is as if the living thing found a way to transcend the limitations that came with the delimitation of its own being, when it took refuge inside a lipid wall that protected it from the outside, and allowed it to create its own little world, distinct from the vast expanses of the sea. More than a language or a true form of communication, this primitive sensory apparatus allows a cell to extend its reach beyond the boundary of its outer wall. Sensors can act as remote switches, activated when they receive a chemical key, which can originate from a very distant living being, or even one that has long passed away. A community of cells therefore slowly becomes a giant living organism, as a labyrinthine web of invisible bonds is woven between them. Each individual living thing can live by itself, but they all also can influence other members of their community, and their behavior can also be shaped by them. This integration of numerous living beings into one radically changes the rules of the game of life. A new layer, a new dimension of the play of affinity and strife will therefore emerge out of this new social nature of the cells, one that will complete rather than replace the previous ones.

The balance between love and war, those who are cherished and those who are fought, will now not only be searched by individuals but also by entire communities. Selection will not only occur on individuals but also on groups, and there may also be tensions between these different levels. Individuals that would be unfit compared to their brethren may somehow benefit the whole more than any other, leading them to survive and reproduce solely because of their contribution to the group. The different layers of the strife for survival will thus also be in tension against one another, until an equilibrium is found between them, one that would lead to an optimal growth of their branch of the tree of life. Because of this, forms of apparent altruism may therefore be observed

in communities of living things, where individuals sacrifice themselves, by accepting to die or simply not reproduce, so that the whole would have a greater chance of survival.

Independent cells may nonetheless adjust their balance between individualistic and altruistic behavior. They are indeed already capable of adapting their behavior to their environment or special events, using their sensors as triggers allowing them to switch between different patterns, which are all inscribed in their library of information but only exploited when it is the precise pattern that will offer them the best chance to survive and reproduce. This is one of the remarkable aspects of this library, which uses series of long lines of bases, a two-dimensional writing line like the one you are reading now, to not only fully represent the blueprint of a highly complex three-dimensional living thing, but also different combinations, different configurations of this living thing that can be deployed in the fourth dimension, time. When the cells find themselves in a place and a time where they are more likely to survive and reproduce by prioritizing their interests over those of their kin, they can adopt an individualistic behavior pattern, distancing themselves from others, giving birth to clones by dividing their own body rather than searching for a lover. There will nonetheless be other places and times, when it will be far more strenuous to make it on their own. Encountering such conditions, they can then switch to a more sociable pattern, described in their library, seeking refuge and strength in numbers, in a community.

The exact nature of the events or environment triggering more social patterns of behavior in the first collared cells is not known, but the behavior of their distant descendants and cousins may provide some clues. One of the most common of these triggers is the presence of predators.¹ Danger may indeed lead such living things to swarm around one another, uniting their forces to withstand periods of war, uniting their efforts to survive, appearing as one giant creature. One could imagine other scenarios where unity would be key to survival, such as extremely cold waters, in which it would be easier for a swarm to avoid freezing to death than for a lone individual. Like fish in shark-infested waters, cells may also swarm to avoid predators that would not be able to ingest the

¹See: Barry S. C. Leadbeater. *The Choanoflagellates*. Cambridge UP, 2015. Page 58.

whole that they form or would simply be intimidated by their massive appearance. As they slowly refined their ability to create and disband such swarms, some communities developed ways to fortify the link between their members, becoming one not only through their sharing of a part of the sea or their possession of common chemical tokens marking their belonging to a fellowship, but also uniting their very flesh, becoming one body, for a time at least.

The ocean is a place of constant tumult. Its innumerable soldiers, water molecules, relentlessly move in formation, forming whirlpools and currents that carry all that enter in contact with them. Their power reflects their number rather than their size, and they thus can overcome the strengths of most living things swimming within their ranks. The feeble tails of the collared cells are largely ineffective to resist the rage of the sea, and when these little bits of life need to gather their forces to withstand an assault of nature or a whim of fate, such as a famine, they may be pulled apart by the waters, which then become as much adversaries as they are providers to them. Countless fellowships of cells surely were forcibly disbanded by the watery host, and led to be reclaimed by the realm of death, as the fire of life was quenched within them. Competing lifeforms may also have played a similar role, ramming into the gatherings and pressuring them so that they would be scattered. Whatever the exact cause, the effect remained the same. A merciless selection occurred. An enormous quantity of lives were sacrificed so that a solution to this problem could be discovered by life. One day, a key was once again found, probably by a single member of a group at first, and a new feature of life was then unlocked, one that would allow its descendants to weather the underwater storms and thwart the assaults of other living beings.

The cell continually secretes a wide range of substances, through the agency of specialized worker-molecules, which are destined either to serve the internal machinery of the cell, or to be employed as signals or offerings to other living things. Some of these may also form defensive coatings or even be venom repelling or attacking enemies. With the regular reshuffling of the library of information that occurs after each sexual encounter, the production of a large number of new substances occurs with each passing generation, each representing an experiment by life itself. As the result of such experimentation, one day a cell secreted a particular combination of substances, notably containing *collagen*, a long and fibrous

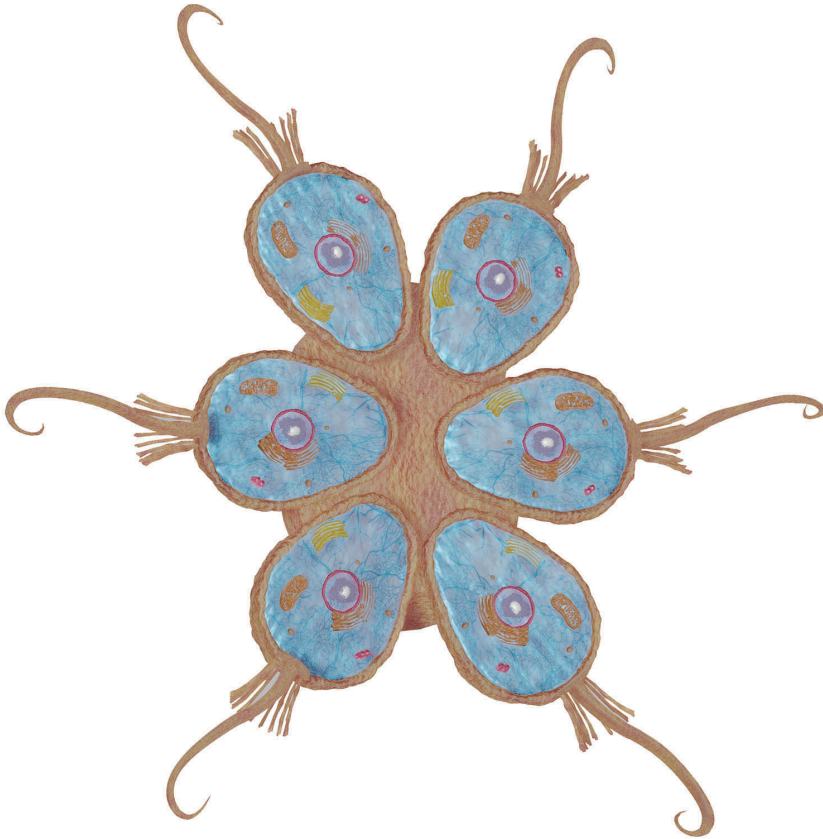


Figure 13.2: *An agglomeration of collared cells.*

molecule whose name literally means “glue-producing,”² which has the property of allying stickiness with elasticity. Coating its outer wall with such a glue, the cell can then bind itself to another of its kind, physically attaching its head to the one of another, relying on the adhesive property of its new discovery to weather aqueous tempests or enemy charges.

The knowledge of the ingenious discovery of the pioneer cell is soon passed on to its descendants, who therefore also find themselves endowed with an ability to attach their heads to others. Facing a threat, originating from the forces of nature or from life itself, they can use their viscous coat to agglutinate themselves, forming a huddle. The secretion of the gluey and yet elastic sub-

²From the Greek κόλλα (kólla), meaning “glue”, and -γέν “producing.”

stance can nonetheless be continued, a substance that will act as a cement forming an increasingly thicker pillar on which each member of this fellowship will robustly attach itself (See Fig. 13.2). This cement is very similar to the one binding our own cells together, and it represents approximately a third of all the proteins contained in our body. It is nonetheless far less impermeable than cement, as each member of this fellowship may use this relatively rigid frame as a foundation for the establishment of routes for exchanges between cells. Their group is not a mere juxtaposition of independent cells, seeking refuge from threats in numbers, but it rather represents the beginning of a new form of relationships between living things.

If the cell can be thought of as a city, their gathering through the adhesive power of the new discovery represents an urban agglomeration, a stable structure composed of different cities that not only share the same territory but also are integrated into a single whole through a network of paths and roads, of different sizes and nature, which allows them to exchange resources, workers, and messages. Groups of free-swimming cells could already perform some of these types of exchanges, but the new rigid frame cementing their bonds allows the emergence of more direct, steady, and reliable routes, in addition to the physical anchorage that it offers. A question may nonetheless rightfully be raised: why form an urban agglomeration instead of simply creating a unified, monolithic giant city? Why wouldn't nature simply select increasingly larger cells that could weather the tempests of the sea or the assaults of other forms of life?

Very large cells are possible, and even macroscopic ones are now known³, but these are rare exceptions considering the immensity of the tree of life. One of the main reasons explaining this rarity is the fact that the machinery of the cell cannot be stretched out like a rubber band. It relies on a very delicate balance linked with the nature of the materials with which it is made. Atoms and molecules, such as the ones used to write the library of information of the cell, have very stable shapes and dimensions. If a cell grows too large or too small, the machinery will be subjected to

³The largest single-celled organism is *Caulerpa taxifolia.*, which can grow up to three meters tall. Such large cells nonetheless have many nuclei, which help them overcome the size constraints of other single-celled creatures.

more stress and strain, until it breaks down.⁴ Furthermore, as a cell grows in size, its volume will increase faster than its surface and, as a result, the larger it is, the more difficulties it will have to absorb enough oxygen and other substances through its “skin” to power its internal machinery. Agglomerations of cells nonetheless allow life to grow in size without suffering from such constraints.

An urban agglomeration differs from a giant city by the relative independence of the different cities that are part of it. Each one of them has its own city government, and it can function without major disruptions even if some of its neighbors collapse or if it finds itself severed from them. New members can be seamlessly added to this agglomeration, without the need for major reorganizations of either the whole or its parts. Relationships can be built between members, allowing them to benefit each other, but in case of the collapse of a member, these bonds can be suspended and substitutes can be found. What an agglomeration offers is an incredible flexibility and adaptability, as each one of its members also represents a pioneer cell with a unique library of information, one that has never been tried by life before and that may lead it to new discoveries. Each act of love during which a new library is created represents a lottery ticket, a chance to allow life to climb a new step of its evolution, and thus a multiplicity of cells is more desirable than a single giant one. As each city follows its own rules and its own leadership, the agglomeration has more chances of discovering new means of governance, inventing new modes of communications, learning new types of relationships with its neighbors, or fabricating new kinds of materials. It allows a continuous search for a perfect balance between the parts and the whole, the need for individuality and independence on the one hand, versus the one for unity and partnerships on the other.

An agglomeration, a colony of city-cells, furthermore represents a union in which all its members share a relatively equal status. There is no central command, no single leadership that would dispatch orders to all cells and would decide their fate. They all share an equal position, even though they all come with their uniqueness, and are all interchangeable. This distributed nature

⁴The same phenomenon also explains why the selective breeding of animals according to their size can encounter a natural wall, beyond which no healthy animal is born. This is why we cannot breed horses of the size of a rabbit, or spiders the size of a cat.

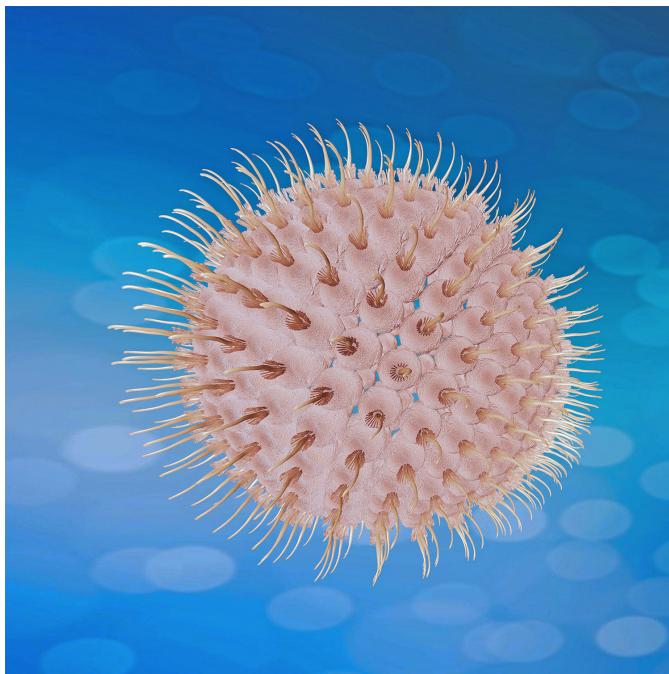


Figure 13.3: *A spherical agglomeration of collared cells.*

of the agglomeration is also one of its strengths, allowing it to transcend the limited lifespan of any of its members. The whole may indeed survive the death of all its founding members, and reach out toward eternity. Like Theseus' ship, which had each one of its pieces replaced and nonetheless continued to represent the long-gone original,⁵ the agglomeration can outlive all of its parts, as its members can father children who can one day replace their parents, holding up the integrity of the whole through an uninterrupted succession of the old by the new.

As agglomerations are multiplied in the vast expanses of water covering the earth, they as a whole also become pioneers, experiments made by life in order for its tree to elevate itself, starting to resemble living things themselves. They are thus caught in the play of love and war, as changes are brought on by love and birth while selection is brought on by war and death, and because of this blessing, which comes in the disguise of a conflict, new forms of

⁵See the footnote explaining the story of the ship of Theseus at the end of Ch. 1.4.

agglomerations can emerge in the depths. A myriad of shapes and sizes are tried, with the sacrifice of entire communities of living beings, whose fire of life is snuffed out and whose bodies are thrown back to death. Different times and places warrant different limits in the number of cells that can join such groups to ensure their survival. As they remain independent living things, the members of each agglomeration may even decide to dismantle it, breaking up their partnership if it is found to be a hindrance rather than a help for their survival and reproduction. The cement binding them may then be dissolved, with each member swimming away and then fending for themselves.

When a union is desirable, agglomerations may nonetheless also distinguish themselves by imitating on a larger scale one of the building blocks of their being, the enclosure marking the boundary of their own body. Arraying themselves in a spherical formation, which can be observed in several species of modern colonial cells,⁶ they not only form a globe but also open up a space similar to the one opened by the lipid spheres in which the first self-replicating chain took refuge soon after the kindling of the first spark of life (See Fig. 13.3). This space represents a new environment, insulated from the rest of the sea, which transcends the limitations of size of the lone cells. Like a jug, whose usefulness resides in its empty space rather than its body, as told by the Chinese philosopher Laozi,⁷ this new space will soon be the basis for one of the most important discoveries of life as a whole.

⁶For more information, see: David L. Kirk. *Volvox: A Search for the Molecular and Genetic Origins of Multicellularity and Cellular Differentiation*. Cambridge UP, 1998. Page 22-25.

⁷See: Lao Tzu. *The Tao Teh Ching*. Trans. by James Legge, Grange books limited, 2001. n.p. (Ch. 11); Original Chinese: “埏埴以為器，當其無，有器之用。” From “CTEXT.”

Re-flection: The Bonds Between Us

The fire of life is fed by the sun and fanned by the winds and currents of the sea, and it spreads as the heavenly wheels unceasingly turn in perfect harmony. This fire forms a whole made of a multitude of cells, a whole surviving the death of its parts, passing through the ages without anxiety for its survival, knowing that a single cell is enough. As long as a single spark perdures, the fire will find a way to rise again from its ashes.

The lone beings nonetheless soon discover the power of the whole of which they are part, as their life is threatened by the earth under them, the life around them, or the sky above. The hidden strength of these beings is in their numbers, and the bonds they form, or those created by life itself that they simply unveil, such as their kinship with other individuals.

Few of us would be able to survive alone, exposed to the rage of nature, for a single month. We buy the food that satiates our hunger, and the water quenching our thirst runs to our home, as we toil inside buildings made by the hands of others to produce things destined to strangers. We rely on our own kind for our survival, just as we need a partner to pass on our essence.

The seed of this trait of mankind emerged during the infancy of life, in ancient and lone cells, as life discovered the preciousness of cooperation, the life-saving nature of proximity with others. The ancient cells that joined their flesh and strengths when starving survived, and thus their progeny passed on their discovery across generations and added their own contributions. When facing icy currents, those that huddled together kept themselves sufficiently warm, while the loners swimming in the vastness of the ocean froze and sunk at the bottom, dead.

By exchanging tokens and signs, living creatures of all stature can define strategies for survival, uniting their fate when they are confronted with a common threat that could annihilate them all. Chemical signals or lengthy letters, they both bind beings with commitments to love or war, subjugating individuals to a greater cause, the survival of the whole that they form.

Holding the hands of other persons, we feel the warmth or coldness of their body equalized with ours. Pulling on these hands,

we notice the weight of the whole, giving stability to all. Distributing our strengths and weakness across the group, we are stronger than any individual, and we are ready to stand against forces superior to our own, confident and fearless.

The most natural bond between beings certainly is the one between parents and children, with them sharing more of their essence and flesh than with any other living thing, as they dwell in a common space, a common world, experiencing the same dangers and blessings. We feel closer to those who share more things with us, and are inclined to love them, whereas the presence of the stranger, the unknown, often kindles animosity and war.

We may remember situations during which our bond with another human being saved our life, noticing how their existence allowed ours to continue, giving us the chance of enjoying this day. By using our tongue or fingers, we called for help and received assistance from others, as they understood our need and took upon themselves the charge of protecting one who is not them. Thankful for their contribution to our survival, we may return the favor to our neighbors, conscious of the need of our kind, and all life, to stand together as one to overcome death, that is, the quenching of the eternal fire that consumes and sublimates our flesh and supports our mind.

If we stay close to other living things, may it not solely be because they feed us, or because we seek to find a member of the opposite sex to satisfy our lust or desire for children. The bonds between us may be more than ways for us to overcome dangers or extend our lives. We can make them the cement binding life itself together, relinquishing the self into the whole. Only then may we experience the entire tree of life as the fullness of our own nature, and feel the entirety of our being continuously and completely consumed by the fire of life. Feeling the whole inside ourselves, we may embrace our death as a brief voyage to the earth, knowing that our flesh will soon be once again part of life, and that the fire is never extinguished.

Chapter 14

One with Many: Multi-cellularity and the birth of the Animal Kingdom

During innumerable years, cells joined their forces to face the hardships of nature: the frontal assaults of life, the sweeping currents of the seas and the winds, the dryness of the earth, or the scorching heat of the sun. Causing wounds or starvation, the tumult of the elements pushed life to struggle, to stand against the gigantic realms in which the tree of life is rooted and grows. Myriads of agglomerations were formed and disbanded, as the whole of life learned the lessons taught by the death of its parts, honoring their sacrifice. With each act of love, of the self or the other, division or sex, new experiments were performed, exploring the space of the possibilities offered to life by nature itself, by the very structure of the creation. Most of them failed, but just as the beauty and rarity of an exceptional diamond can make the meticulous sieving of a whole mountain worthwhile, life was ready to fill the seas with the cadavers of its own children to allow its offspring to rise further, toward the sky. The death of all but one of them is tolerable if this pioneer succeeds in making an invaluable discovery, one that will allow its descendants to grow more numerous and fitter than all those who were sacrificed for it. One of such

discoveries occurred when one cell exhibited a simple and yet peculiar property: each time it divided, the two cells that it formed failed to go their own way, and rather stayed closely attached to each other.

Inside the pathfinder cell, within the enclosure formed by the rampart of this spherical city, innovations appear. Perhaps, as can now be observed in many lifeforms, the network of lanes and pathways that pervades it now slightly protruded out of its boundary, piercing the outer wall to reach out to what lies beyond: another city. It may also have developed a tendency to secrete the gluey substance used to form agglomerations, which normally was only used when an existential threat was encountered, but would now be used from the time of its birth and during its entire life. A combination of the two is also possible, but one thing remains certain: this failure to separate from its parent presented an advantage to this pathfinder, and this attribute was passed on to its descendants, among which all animals, including ourselves, can be found. The two agglutinated cells divided further, forming a cube composed of four spheres, each one of them bound to two others, on different sides. This expansion went on and the four cells became eight, adopting the shape of a relatively irregular sphere. The eight then became sixteen, and the sixteen, thirty-two. At first forming a compact sphere, filled with cells, the structure then begins to change, as an empty space is opened at its center, growing larger as the sphere itself is inflated under the impulse of new divisions. Soon, this formation of cells replicates the structure that was adopted by some of the free-swimming cells, when hard times required that they form an agglomeration, a colony: they draw the contour of a sphere, opening up an empty spherical space within this new border that they form. This allows each one of them to use their collar and tail, and offers them access to the expanse of the water and to the inner space shared by the members of this structure alone.

What has been witnessed here is the emergence of the first agglomeration that is not the product of the association of a community of independent cells, binding themselves to each other to fend off a threat before going their own way again once this fellowship is no longer found to be more beneficial than a solitary life, but rather one that will be permanent, lasting the whole life of the cells, and often even outliving many of them. Each member

is a direct descendant of the founder of this agglomeration, rather than random individuals simply sharing an environment. They all share a single fate, unable to part ways with their companions, and they therefore are invited to cooperate, forming lifelong bonds. Contrary to the temporary agglomeration of free cells, their very existence is ineluctably linked to the one of their neighbors, and the community that they form as a whole. They cannot abandon a decaying fellowship. They cannot forsake the weaker links in the chain that they form. This apparent weakness would nonetheless soon be shown to represent the greatest strength of this new form of partnership between living things.

The first cell to have been endowed with the capacity, or been laden with the burden of being permanently tied to its descendants, as if they lived under the yoke of an overprotective mother who would not grant them freedom, experienced the burning of a bridge, a fundamental and (almost)¹ irreversible transformation of the nature of its kind. Its offspring are not offered the possibility of looking back, to see the benefits of solitary life. They are only offered one path: the one of mutual benefit, of solidarity between members of a community, and perhaps foremost one of rapid adaptation to this new paradigm. Their life will indeed be radically different than the one of their free-swimming ancestors. They are like a group of prisoners tightly chained to one another. Their movements are heavily constrained by the presence of the others. They cannot wander in the sea to find food or a mate. They cannot flee quickly, on their own, if they encounter a predator. If they need to move, they can only do so as a group, but as they form a sphere, with their tails pointed outward, even beating them all together would only lead them to remain still, the movement of one of them being canceled by the one of another. They therefore are, from the very first generation of this new community, set to run a race to find ways to overcome the disadvantages of the burden of the chains and the group or perish.

All sharing a common fate, the cells are therefore heavily pushed toward a greater communion, a deeper integration of the

¹Cancer, for example, can be seen as a reversion from multi-cellular to unicellular life, with cancerous cells living on their own without regard for the whole of which they were once part. For more information, see: Han Chen, et al. "The reverse evolution from multicellularity to unicellularity during carcinogenesis". *Nature Communications*, vol. 6, no. 1, Mar. 2015, p. 6367

life of each one of them into a single whole. Countless groups surely were wiped out, probably forcing rediscoveries of the secret of the group-forming chains, before one of them succeeded, but we know it occurred. Each city-cell developed stronger ties with its neighbors, and together, after many unfruitful experiments and the sacrifice of a multitude of similar communities, they started to accept their fate, the fact that they were now bound to each other until death, and therefore needed to adapt to this new reality, discarding functions that are redundant or useless, while developing new ones, needed by the whole that they now form. A play then emerges, one that is similar to the one played by the cells involved in sexual encounters and that led to the emergence of two different and complementary types of reproductive cells: males and females. The whole community of prisoner cells indeed needs to solve a wide array of problems imposed by the new paradigm of permanent adherence of all members of the agglomeration, but each one of them is tied to specific constraints, which may be opposed to those of another. A series of tensions thus arises within this type of community, as they are continuously selected for their fitness, their ability to survive and reproduce. Survival may be correlated to the capacity of the whole to move itself toward a precise location, where food would be abundant, or safety ensured, for example, and this would demand that the cells spend a large amount of their energy to produce the wave-like motion of their tails, an energy that would therefore not be available for other tasks. Reproduction, on the other hand, would demand a considerable amount of energy and resources for the cells. Fortunately, here appears one of the strengths of this new form of partnership between living things: forming a single whole, sharing a single fate, they may therefore entrust certain tasks to individual members, carefully selected for their ability.

As each division of the members of the agglomeration comes with slight random variations of their library of information, experiments are done by the whole, with the nature of its members allowed to drift further and further away, if it benefits the group. The more numerous the members, the faster this process occurs, and it was immediately put to use to solve one of the most pressing matters of this community of prisoners: the reproduction of the whole. Indeed, if every member continues to divide itself without limits, the group would grow exponentially and very quickly

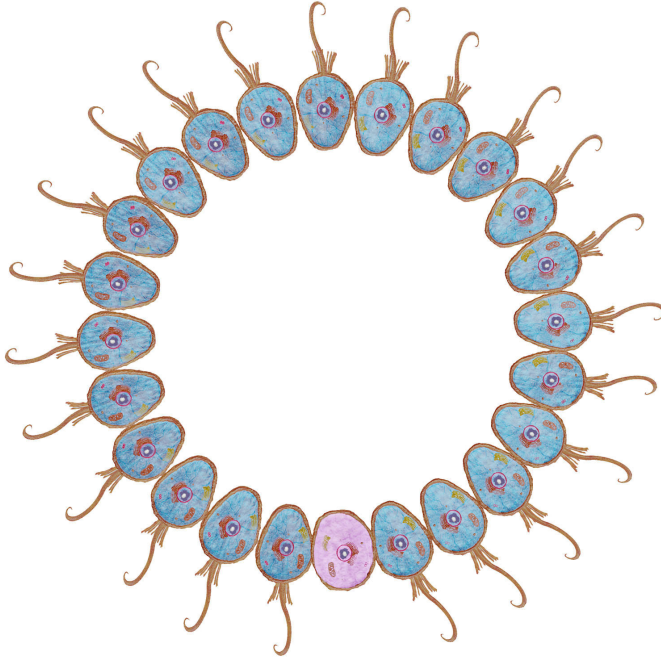


Figure 14.1: *The emergence of a distinction between general cells (in blue) and a reproductive cell (in pink).*

smother itself to death, and it without a doubt happened a considerable number of times before an adequate solution was found. As the result of one experiment of such communities, one member developed a unique quality: an ability to give birth to a free daughter cell, one that would not be bound in chains to the group and be allowed to wander in the vast liquid expanse of the ocean, forming the seed of a new fellowship, whose members will nonetheless never enjoy such liberty (See Fig. 14.1).

The ability to sow seeds of new communities confers a clear edge over its neighbors to the group that has first discovered it. These neighbors will continue to divide and grow until they exhaust the resources available to them, whereas the seeds will grow in new, virgin territories. This is why its kind will flourish, while others will wither, and their corpses will leave life and be brought back to death. By separating reproduction from the other needs of the community, such as motility or feeding, the members of the whole can develop other skills, whose development was before constrained by the need for every member to pass on its library of

information, the essence of its being. Contrary to lone cells, whose freedom comes with its burden, that is, the need to possess a sufficiently wide range of abilities to live on its own, the members of these new communities can lay part of their burden on others. Experiments by the group can grow more daring, as the spreading of the weight of the burden on the whole provides a safety net to each individual cell, which may rely upon its neighbors to satisfy needs that it would no longer be able to fulfill on its own. The prison of communal life therefore also comes with its own new freedom. Individuals can develop their uniqueness, focusing on outperforming others on a single task for example, while remaining part of a whole that offers them safety in exchange for the relinquishing of their independence. This nonetheless comes with a catch: as only a single kind of cells will reproduce, the blueprint of the whole community, including the peculiarities of each one of its future members, will have to be stored in the library of information of these seed-cells if these seeds are to form new communities that would inherit the wealth of discoveries of their ancestors.

Once again, the prodigious problem-solving power of life, its intelligence manifested through the allying of experimentation and the selection of living things, led to a very ingenious solution to a practical challenge faced by life: the question of how to regenerate an entire community from a single reproductive cell, without losing the peculiar skills discovered by its members. This solution is centered around the library of information of the seed-cell, but its implementation heavily relies on the crucial role played by the librarians, the working molecules that use the library to shape the life of the cell. Until now, the library mainly contained the blueprint of a simple cell, like a three-dimensional plan expressed in terms of proteins and molecules. With the emergence of an alternation between replication through cell division and sexual reproduction, the library and the work of the librarian grew more complex, as different parts of the compendium could be used at different times, changing the nature of the cell without changing its essence, its central library. This marks a transition, which cannot really be pinpointed and may very well have occurred long before the emergence of sex, from a three-dimensional knowledge encoded in the long chain to a four-dimensional one, one that is unfolded according to the development of the seed-cell into a community.

The library of the seed-cell, a copy of which will be found in

every single future member of the community that will sprout out of it, can contain a plan, a program determining the fate and nature of its descendants across multiple generations, even possibly determining at which point their line will end by rendering them unable to divide themselves. As the entire edifice rests upon the reproductive cell, it is on it alone that the redaction of this plan depends. Entire generations of communities therefore have to be sacrificed through experimentation so that discoveries can be made, and the plan can grow in efficiency, complexity, and duration. Letter by letter, molecule by molecule, this plan becomes clearer and is stored in the stacks of the library, with countless seeds thrown on sterile ground before one can germinate, discovering a new land for life, which may take the form of a single letter-molecule added to the gigantic volumes of the library. As this exploration continues for millions of years, the severe selection endured by the seeds causes the emergence of incredibly complex plans, refined during long periods of time. As a result, a single seed-cell may now become the source of something more than a mere agglomeration. If the individual cells are cities and a gathering of them formed urban agglomerations, the fruit of the development of such seeds is something more, something that combines the wholeness of a single cell, a group in which the parts are entirely dependent on each other in order to live, with the flexibility and adaptability of the agglomeration: a metropolis, an immense city without a center of decision but nonetheless exhibiting a high degree of integration between its parts, with different areas specialized in the accomplishment of different tasks, all for the benefit of the whole.

Each seed represents a city-hall, around which the city begins to be constructed, following the plans devised and stored inside it. This place nonetheless does not represent a seat of command, as its wealth of information, the library and its servants able to exploit its knowledge, is duplicated and present in each new city-cell, part of this growing metropolis. With each division, it grows larger and the first seed soon loses its importance, to become a mere cog among others in this new, titanic machinery. Each area of the metropolis possesses the whole plan for its development, not only across space but also across time: its past, present, and future, until its death. Each one of them is nonetheless not interchangeable, as their own nature and the role they have been assigned to play

for the metropolis is also (partly²) contained in the plan found in their common library of knowledge. The plan is unfolded through their agency, through their very flesh, as different parts are given different tasks to complete. Some will be in charge of finding nourishment for the community, while others may be given the task of processing, digesting the food found by others, and finally, some will be entrusted with the crucial task of perpetuating the heritage of the metropolis, by creating seeds of new communities that will be released in the vastness of the ocean, using their treasury of knowledge to conquer new domains and flourish.

The unfolding of the plan across the fourth dimension therefore includes the determination of the fate of each cell. Some of them only develop a special shape and function only after a predetermined number of divisions of their parent, while the metamorphosis of others may be triggered by signals sent by different cells. Finally, some of them may conserve an ability to change their own nature all their life, ready to reinforce a part of the metropolis that would experience a lack of certain specialties. The plan is nonetheless not limited to this assignment of the roles played by different parts of the whole. It also contributes to the determination of the outer frontier of the metropolis, one that would represent an optimum fitness, a perfect balance between the size of the group and its sustainability. By limiting the number of generations that a cell can father, the size of the whole or some of its parts can be precisely tuned. A greater size implies a demand for a greater tribute from the earth and the sky, more natural resources, but also greater energetic efficiency.³ A smaller size may allow faster development and reproduction, something advantageous if this lifeform finds itself in a highly unstable and noxious environment, demanding a rapid evolution and adaptation to survive. An almost infinite array of causes may influence the determination of this optimum size, but no matter what they are, the result is the same: the fittest

²The fate of each cell is also influenced by the signals it receives, from the other cells in contact with it as well as from signaling substances, hormones. A famous example is the “induction” mechanisms by which the fate of cells is determined by the presence of certain types of cells around them. For more information, see: Lena Gunhaga. “The lens: a classical model of embryonic induction providing new insights into cell determination in early development”. *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 366, no. 1568, Apr. 2011, pp. 1193–203

³This phenomenon is known as *Kleiber’s Law*.

prosper while the others go extinct, and through this selection a balance is kept between life and the forces of nature. Because of the diversity of the seas covering the earth, there will therefore never be an ideal solution. Lone cells will continue, to this day, to reign in some parts, while larger living structures, such as the aforementioned metropolises, will continue to occupy and conquer other domains. One tendency will nonetheless be noticeable: even though the simplest forms of life will remain, life as a whole tends toward an increasing complexity. The most voluminous libraries of information grow larger with the passing of the eons, and the plans that they safeguard grow in complexity and duration, their unfolding spanning a longer length of time.

Finally, another critical transformation of the living metropolis that can be planned from its birth is its shape. The exact manner in which such changes started is not known. One possibility would be that once an empty space was opened by the spherical arrangement of the dividing cells, some of them may have been programmed to fold parts of this sphere inward, perhaps as a means of protection for the most crucial of them all: the reproductive cells. This may also have been done in the same manner as most organisms do today, that is, by breaking the symmetries of the forming sphere, unequally dividing certain cells, unbalancing the nascent structure, in order to shape it, as if a potter shaped a piece of clay as it was growing. Protection of the reproductive cells is nonetheless only one of a multitude of reasons that would push the metropolis to cease to adopt a spherical shape. The multifaceted creatures are severely selected for the fitness of their distribution, for the efficiency of their form, according to a considerable number of criteria, some of which may be the source of inner tensions, as they may oppose each other. The result of such selection, associated with the other, aforementioned ones, would soon lead to the sprouting of what certainly is the most majestic and refined branch of the tree of life: animals.

The first creatures that can be considered animals arose as a result of the emergence, following a selection, of complex and efficient plans for the development of seed-cells into large living things, composed of a myriad of individual cells relying on each other and forming an integrated whole. One of the most successful innovations that emerged as the product of the selection according to their shape was the formation of cavities, with motile

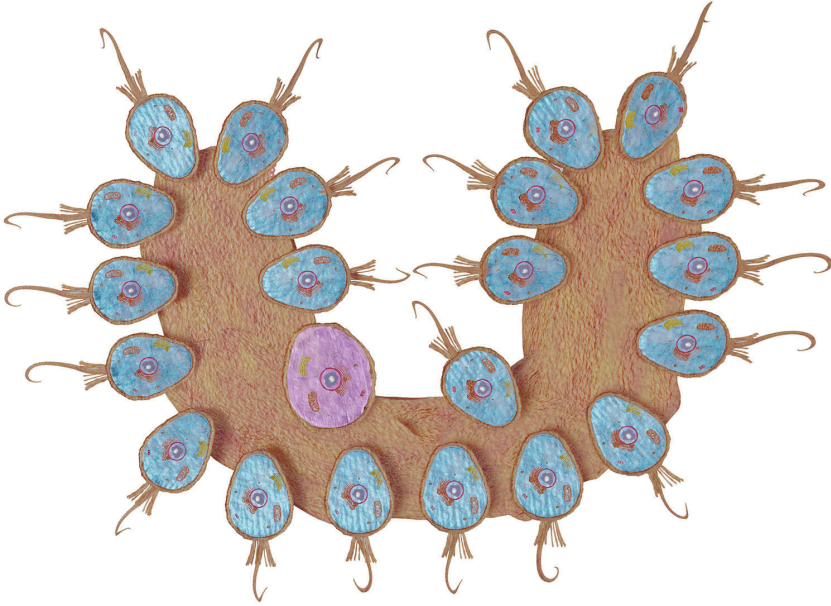


Figure 14.2: *Formation of a cavity by a primitive animal.*

cells on the outside surface, bound together through the secretion of a substance similar to the one used by their distant ancestors to form agglomerations during a time of needs, acting like a mortar with which a precise structure can be formed (See Fig. 14.2). The most obvious reason explaining the success of such arrangements of cells may be an increased ability to gather food, with the cavity acting as a sort of trap and the tails of the cells used to create a flow of water that would deposit minuscule living things floating in the water, or simply the pieces of formerly living things, inside it so that they can be absorbed and digested, either by the motile cells themselves or by specialized ones. The necessity for all cells to have access to the oxygen dissolved in the water could be another constraint favoring the formation of thin structures, filled with holes and cavities, like a sponge. And this is no coincidence if sea-sponges are precisely the first and most primitive kind of animals.

Sponges may appear to our eyes more similar to plants than other animals, but they share more with us than with them. They come in an extraordinary range of shapes and structures, but they generally form sets of tubes, which are used to create a flow of

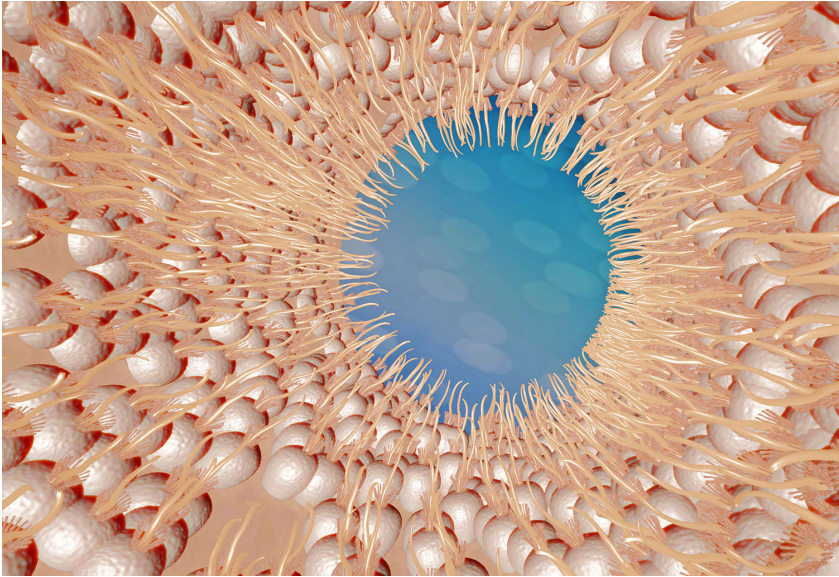


Figure 14.3: *Tube formed by a sea sponge, lined with cells with collars and tails.*

water that passes through them, assisted by a large number of cells equipped with beating tails stirring up the liquid, allowing it to collect the particles of food carried by the sea, in addition to oxygen (See Fig 14.4). Sinuous networks of galleries and tunnels channel the minuscule soldiers of the sea into the animal's lair, its own body, so that it can extract a tribute from them, taking the corpses of past living things or even living cells that they would otherwise carry around the ocean. The gigantic metropolis, formed by billions of city-cells working together in almost perfect harmony, meticulously applying the plan devised by its ancestors through the sacrifice of an astronomical number of generations, with one purpose: to live and reproduce. The scale of the astonishing evolution triggered by the ability of a seed-cell to program the development of an animal across multiple generations of dividing cells is hardly fathomable by our mind. The simplest and first branch of this new kind already produces creatures that are already billions of times larger than the solitary cells that came before them, and from which they descend. The spreading of the burden of survival and reproduction upon the whole creature rather than individual cells has permitted a considerable acceleration of their evolution. The larger the creature, the more numerous are the chances that

cells within it would discover new traits that would benefit the whole, traits that would be selected if they improve the fitness of the animal. The variety of the sponges would therefore in a short time surpass the one of any of its distant ancestors, the lone cells or the ones exhibiting rudimentary social skills.

There is nonetheless one peculiarity that would soon be shared by all sorts of sponges: their relationship with the earth. Most of them have indeed ceased to be free-floating creatures, letting themselves be carried by the currents, manipulated by the winds, the heat of the sun, or even the tides initiated by the moon. They are animals attached to a part of the earth, creatures securely anchored to the rocky floor of the ocean. This branch of the tree of life thus takes a stand in the strife between the forces of nature, allying itself with the soil and thereby ending its subjugation to the whims of the waters. If those belonging to their kind that survived and passed on their legacy all underwent such a change of alliance, it is nonetheless because it was necessary for them. This Copernican revolution, a radical change in their point of reference, from one tied to the ever-changing current to one linked with the seemingly immobile and unchanging earth, indeed allows them to more efficiently extract a tribute from the soldiers of the sea. Sponges feed by filtering the flow of water that passes through their tubes, holes, and cavities, but if they are themselves carried by the same flow, floating or swimming in parallel with the particles that they intend to absorb, they have to rely entirely on the strength of their feeble tails to bring new water inside them, to let in new ranks of the host of the sea so that they would be trapped and forced to give up the wealth that they carry, an inefficient strategy. Some of them, when entering into contact with the rocks lining the seafloor as they were pushed by the currents, nonetheless started to bind themselves with them, perhaps using the same mortar as the one binding their cells together. Holding its grip on such mineral ballast, the sponge experienced a considerable increase of the flow passing through it, as it stood still relative to the entire earth, while the waters continued their endless race around it (See Fig. 14.4). This, in turn, provided this pathfinder sponge with a substantial advantage over the other members of its kind, as it could absorb far more food and do so more easily than them, and in case of scarcity of food or dangerous living conditions, it will have far better chances of surviving and passing on this newfound capacity

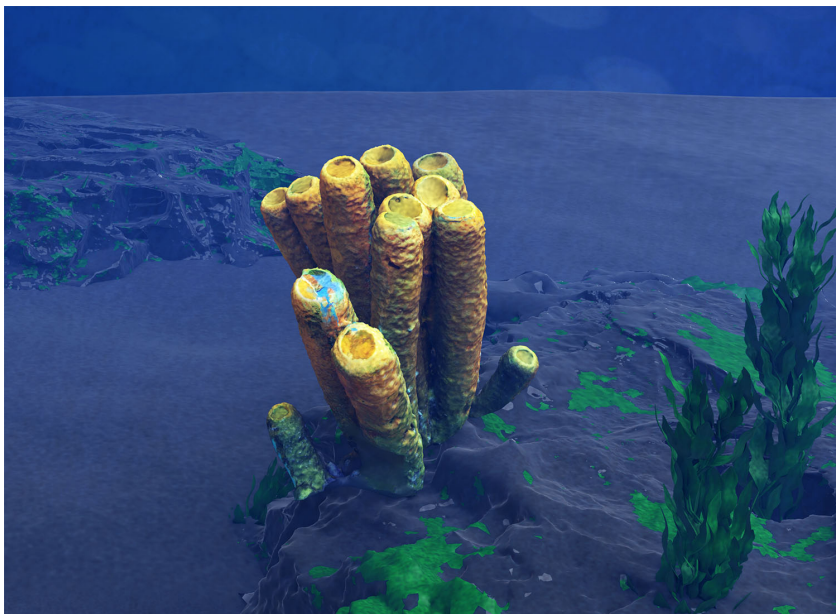


Figure 14.4: *A sea-sponge.*

to attach itself to the earth.

By standing out of the currents by which it was carried until then, the sponge can finally exploit them. It has traded the motility acquired by its distant ancestors, the cells equipped with a tail that now serve to stir up the waters and stimulate its flow, against an easier access to the wealth of the sea and some stability. Before, as it was a free body carried in the sea, without any reference point except itself, it knew no direction and was insensitive to the arraying of the different forces of nature. Continuously tumbling in the waters, there is no up and down, left and right, only an opposition between the self and the other, the inside and the outside. This nonetheless now changes as the sponge is permanently attached to the rocky soil at the bottom of the sea.⁴ It will now mainly grow in one direction, upward, as the nature of the earth that provides the creature with the stability it needs, its rigidity, its hardness, also implies that it will not allow the living thing to penetrate it, contrary to the water, whose fluidity renders it useless as an an-

⁴Sponges may nonetheless move, albeit very slowly, only a few millimeters a day, using specialized shape-changing cells similar to amoebas, which are found in their body.

chor point but allows creatures to grow within the space that they open up. The sponge therefore finds an equilibrium between soil and water, firmness and softness, and it flourishes between them. It has no sense organs and therefore no knowledge of directions, but it nonetheless through selection develops an orientation, unknowingly extending itself toward the surface and toward the sky that lies beyond it. The spherical geometry of the living thing, linked with the freedom offered by a life of liberty in the vast expanses of the ocean, is now superseded by a more tubular one, more adapted to a sedentary life on the seafloor, as it combines a radial symmetry ideal to let water flow in with an elongated shape that allows the sponge to reach out upward, to the currents of water flowing above the floor. By offering the sponge a reference point, the earth therefore also reshaped the creature, breaking one of its symmetries, once again showing the power that it can exert on the third realm, the child growing on its skin.

The evolution of the first animals into sponges was nonetheless not limited to a change of outward appearance, or of general structure. This metamorphosis was based on a radical transformation of its most fundamental components: cells. As the experiments driven by the seed-cells grew more daring and their discoveries were slowly added to their library of information used to build the whole creature that will arise as the result of their division, new types of cells emerged, endowed with increasingly unique skills. These cells become the artisans of the animal, diligent workers whose devotion to a single task renders them more capable and more efficient. This first and most primitive of all animals already exhibits a remarkable wealth of diversity. In addition to the now familiar cell equipped with a tail and collar that is used to stimulate the flow of water, among other functions, there are specialized skin-cells, which are thin, elongated, and smooth. The beating of the tail on the outside surface of the creature only representing a waste of energy, they have therefore been replaced by more frugal ones (See Fig. 14.6, in dark green, on the right). They can protect the outer part of the living thing with their own body, which is more resistant than the one of other cells, and their large surface allows the creature to save more energy by employing fewer cells for this task.

Other cells also perform unique functions. Some are devoted to reproduction, while others take charge of digesting food. Some

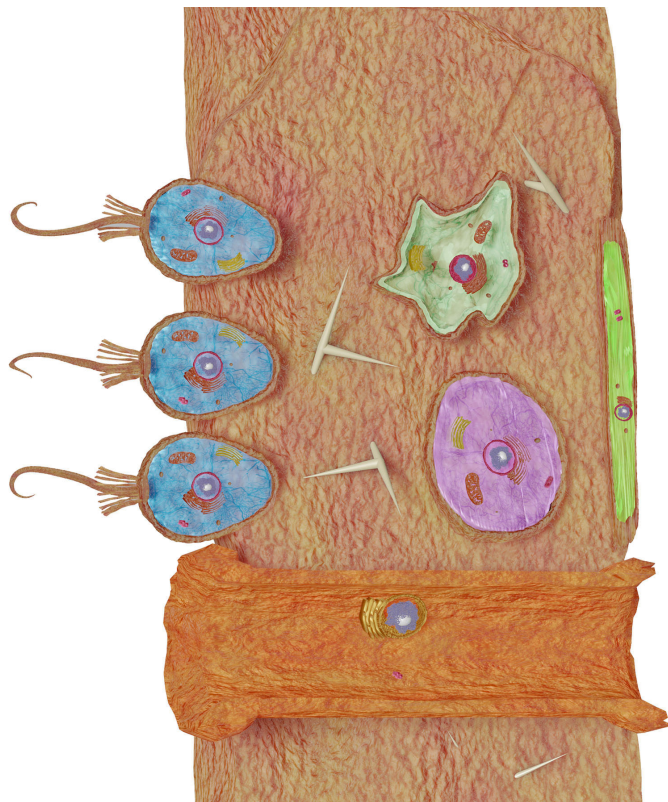


Figure 14.5: *A closer look at the microscopic structure of a sponge.*

form small tubes that can control the outflow of the water contained by a larger structure, and others secrete the mortar that forms the major part of the frame of the creature. The intelligence of life also led to the discovery by the sponge of the advantage of mixing a ductile mortar with rigid filler elements to provide support to a structure, which could then grow in size without risk of structural collapse, like reinforced concrete. Special cells therefore fabricate small rigid objects, often assemblies of spines, that are inserted into the walls of the sponge, allowing it to combine strength and flexibility.⁵

One should nonetheless keep in mind the fact that despite this great variety present inside the sponge, these skilled artisan-cells are all the children of a single seed, whose library of information contains the blueprints of all of them, in addition to the general layout of the entire animal. Furthermore, the great majority of them will die without reproducing sexually. They divide themselves to form the body of the sponge, but only one kind of them, specialized for this task, will be able to encounter a partner and experience sex. Only they will be allowed to transmit the library of information, nonetheless belonging to and shared by the whole organism, to a new generation, a new animal, although this library will be shuffled with the one of its lover. This situation implies the existence of two perpendiculars “bloodlines.” The first is the one of the reproductive cell(s), which is potentially immortal and thus can continue indefinitely, passing through the ages as it evolves and is shaped by the earth, the sky, and the rest of life. We, as human beings, are the direct descendants of this line, an uninterrupted chain going from the first living thing up to the first sponge, and unto each and every one of us. The second one, representing the bulk of the body of the animal, is on the other hand severely limited in its extension. The cells belonging to it will be allowed to divide themselves until the appointed time, determined in the library, but each one of them will die together with the organism that they form, without leaving any offspring that would outlive it. (See Fig. 14.6, the reproductive line is represented vertically, the second one horizontally.)

The decoupling of the line of the cells of the body from the

⁵These little objects are technically called *spicules*. The reader is invited to look for pictures of them as their variety and beauty make them worthy of discovering.

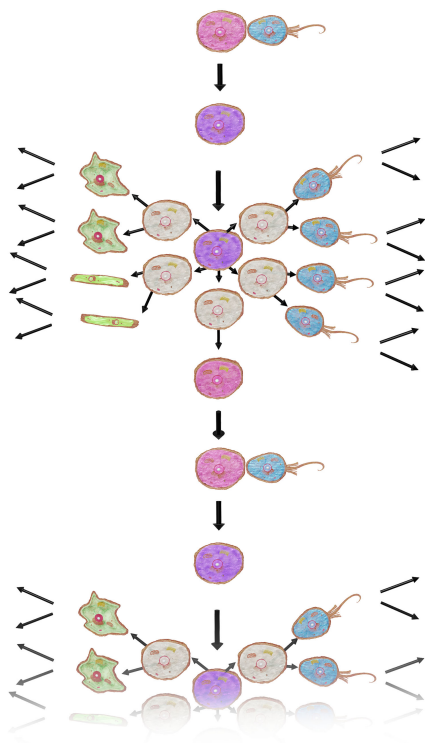


Figure 14.6: *The reproductive line (vertically) and the rest of the body (horizontally).*

reproductive one can be seen as representing a concentration of power within the metropolis formed by the animal. Like the library and its servants within the city-cell, the reproductive cell becomes the center-point of the whole structure, the one that must be protected at all costs, as the entire edifice rests on it. This is why they are found in the most secluded space of the creature, least exposed to external threats. In the case of the sponge, but also perhaps all animals, the entire body, the countless cells working for tasks other than reproduction, may be considered to be a mere conglomerate of expendable individuals, created to serve an elite that will be in charge of perpetuating the life and knowledge of this metropolis. These faithful workers accept their fate, their death and absence of direct descendant, forming a rampart that protects and serves the seeds of future lives, like an army of knights, peasants, and artisans sacrificing themselves to provide and protect an infant, the sole heir of their kingdom. One for all and all for one, the life of the animals is indeed somewhat chivalrous. This choice has nonetheless not been made by all types of multi-cellular living things. Each cell of a plant or fungus can indeed potentially become a seed-cell, but if both configurations exist, it is because each one of them was more adapted to a particular kind of creatures, a particular time, or a particular part of the sea.

The revolution brought on by the discovery of the advantages of the formation of large organisms would soon lead to an explosion in the number of branches of the tree of life, as well as of their size. The acceleration of the evolution of life caused by the lessening of the risks tied to experimentation by multi-cellular creatures also led to an increase in the pace of the arms race between individuals and even entire branches of the tree of life, as each continued to struggle to overcome competitors. The body of life grew in size as well as in diversity, occupying more and more of the seas, but even though this body now becomes more complex, and is composed of increasingly larger individuals, the whole of life is more than ever dependent on the humblest of its members, the basis of the pyramid that it forms: the light-workers that harvest the envoys of the sun, as they are the ones feeding the fire of life with the fruit of their efforts.

Re-flection: The Multiplicity Within Us

Buried deep in the heart of cells, knowledge is accumulated and preserved by life itself. These living things patiently evolved, refined to better fit the earth, the sea, and the sky, becoming minuscule and marvelous feats of nature, exhibiting a prodigious complexity. Passing through the ages, they solved increasingly complex problems posed to them, standing up to the earth and the sky by growing stronger, fiercer, and more resilient.

The growth of the cells was nonetheless reined in by the nature of their machinery, built with atoms and molecules having rigid dimensions, and mechanisms tied to their scale. Unable to stretch out this machinery as the arms race between creatures raged in the sea, certain branches of life discovered the power of the complete dissolution of the self in a whole.

Staying tightly bonded together from birth, cells formed a whole stronger than themselves. No single cell would be able to ingest them and extinguish the fire of life within their wall, whereas they could work together to provide for them all, binding their fate and their substance. The line between the parts and the whole is then blurred, and all that remains is life.

Observing our own body, this mass of trillions of cells joined together and working in harmony, we should remember that all of them are the fruit of the division of a single one of them. Inscribed inside each one is the map of our whole body and of its development, from the day of our conception until the one when the fire will depart from our aging body.

We should try to face the ungraspable nature of our being, touching our skin with our fingers, realizing that each one of the cells forming our body is replaceable and expendable. Our self is not to be found in any of them, as any of them can vanish without consequence, but it only emerges as the fruit of their congregation, consumed by the fire of life.

Our consciousness is an emergent property of this community of cells of our body, something both earthly and heavenly, found between the individual cells, sparks of life, and the entirety of the tree formed by all the bits of earth consumed by the fire. We stand, caught between the minuscule and the gigantic, the parts and the

whole of life, and we are offered the choice of turning our eyes toward either one of these directions. We may turn ourselves toward what we can touch, observe, and possess with our hands and mind, or we may set our eyes toward the horizon of life, forgetting ourselves in the whole.

The observation of our flesh is nonetheless the surest path guiding us to see the tree of life beyond it, and inviting us to perceive the need for variety within life for it to surmount obstacles. Passing our hands in our hair, on our cheeks, and then on our lips, feeling our teeth underneath, We may feel the diversity of cells present within our body, each one of them playing its role.

Each cell of our body is helpless on its own, and only in the whole do their peculiarity shine, as they have been entrusted with a particular role in the gargantuan machinery of our being. The light-sensitive cells of our eyes are useless without those of the brain allowing vision, and the blood cells flowing inside our veins would be superfluous without the heart. Like cities, which arose when men discovered the considerable benefits of division of labor, life built organisms composed of massive numbers of cells, allowing them to become specialized.

The nails at the tip of our fingers are hard and insensitive, whereas our tongue is soft and touchy. There is no central command of our body, as each cell follows the plan inscribed in its core, nonetheless adapting its machinery according to the signals it receives from others around it, but each one knows its role and selflessly performs its duty, without awareness or feeling.

This gigantic mechanism of life was shaped by the earth, life, and the sky, as cells did. It has been finely tuned to take part in the play of affinity and strife, love and war, with the entire body built to survive assaults and to perform the ritual of love and life-giving. If there is one uttermost critical type of cell in our body, it is not those of our brain, but rather those that will ensure the continuity of the burning of the fire once we will be ashes.

Inside our womb or testes, there lies the treasures of our being, the wealth of our ancestors. The rest of our body may be seen as mere protection, a servant of these cells, with our minds driven to satisfy their desire for union with the fittest partner we can find. Our deepest instincts are to help these cell fulfill their destiny, as

they hold the key, they are the posterity of our being and the future leaves of the tree of life. The decision to oppose or follow these instincts is nonetheless in our hands and our minds, as our kind alone has been endowed with the chance to transcend our nature and be more than fire.

Chapter 15

Swimming Vessels: Muscles and Complex Life Cycles

The “bloodline” of our ancestors continues to patiently grow and evolve, as the earth performs countless revolutions around the sun, and the earth, the sea, and the sky are continuously transformed by this celestial dance, taking life in this whirlwind. Legions of increasingly larger creatures are brought to life, each one of them representing a unique specimen, an experiment made by life itself to unveil new chances of evolution. The advent of the union of large numbers of cells to form a single living thing has considerably increased the pace at which life explores all the possibilities offered to it by the very structure of the creation. After many attempts and many deaths, seed-cells have found ways to plan in more detail the shape of the creature that they will form once the great plan of their divisions has been unfolded completely. By finely tuning the way by which such seeds and their daughter-cells divide, in which direction, for example, a structure can slowly emerge, structure that becomes more refined with each round of division.

The somewhat chaotic arrangement of the sponges, with their uneven shapes and proportions, is therefore unhurriedly perfected. In places where their selection is not severe, where no pressure is exerted on them, these sponges will remain, relatively unchanged,

but some of them will be forced to evolve or perish, and their line will ultimately give birth to mankind. The serpentine tubes of these sponges will acquire a more regular shape, helped by the emergence of a key aspect that will be shared by most future animals: living tissue, sheets or masses of densely packed cells. Contrary to the sponges, whose body is formed of various types of cells inserted in a sort of flexible organic mortar filled with reinforcing spikes, these new forms of life are made of two separate tissue layers, each formed with different kinds of specialized cells. The emergence of these two layers occurs relatively early, after only a few rounds of divisions of the seed-cell. One layer will form the inner tube of the creature, the one mainly used to ingest and digest the food that will feed the fire of life burning inside the creature, while the other will form its flesh and its skin.¹ A gelatinous filler substance remains between the layers, but its role is considerably less important, as the creature no longer relies on it for structural support, but rather on the tissue layer themselves, that is, on living cells rather than a “dead” mortar. The creature thereby gains control over its own shape, its own body. It stands up upon the rocky floor of the sea, not relying upon spikes of hardened pieces snatched from the hands of death, but on the living parts of itself, cells that gradually discover ways to support the whole of which they are part.

The so-called polyp stage of a jellyfish represents an example of such creatures, which emerged soon after the sponges and also forms one of the first shoots of the animal branch of the tree of life (See Fig. 15.1). One major difference with the former is the fact that contrary to the tube-like sponges, which let the waters pass through them from one side to the other, the two layers of tissue forming the polyp rather form a vessel, trapping the food carried by the soldiers of the sea in its mouth on top, helped with its circular array of tentacles surrounding it, which act as a funnel. Like the sponge, the polyp therefore anchors itself to the earth to take advantage of its stability and immobility relative to the continuous flow of the waters of the sea, as it allows it to extort tribute from the soldiers of the sea who carry a wealth of food through the paths of the deep. Once they pass through the circular gate, lured in by the rank of tentacles that invite the passer-by, their treasure

¹The inner layer is technically called the *endoderm*, and the outer one the *ectoderm*.

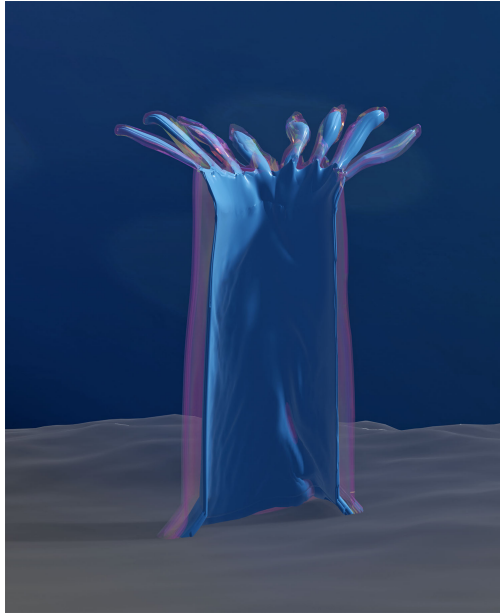


Figure 15.1: *Frontal cut a polyp, with the inner tissue layer in blue and the outer one translucent.*

is absorbed by the wall formed by the inner layer of the creature, its gut. This represents one of the discoveries of this new branch of life, the efficiency offered by a digestive cavity specialized in digestion. It allows a fundamental separation between the inner layer of the body, delimited by the gut tissue, and the space opened by the vessel that it forms, which contains what is meant to be filtered and digested. The creature is not a tube, like the sponges, but rather a jug, with a harder outer layer built to resist the assaults of the earth and the sea, and a softer, inner one that nonetheless may reveal itself dangerous to those venturing inside this vessel. By segregating and insulating the inside from the outside of the creature, what is to be protected from what is to be dissolved and digested, the living thing can indeed grow increasingly aggressive in the way it breaks down the living or dead matter that passes through the threshold of its mouth. The gut can secrete corrosive substances that would break down its food into small bits that could be digested by individual cells, having itself learned to develop a certain immunity to its effect, without corroding the rest of its own body, which may still be vulnerable to them.

Being a vessel rather than a tube, the polyp is therefore presented with a challenge: the need for its mouth to be able to excrete wastes as well as to ingest food. The random whirling of the soldiers of the sea would be insufficient to perform this task. Furthermore, the creature would need a way to separate times when things are let in from those when they would be thrown out. With its tissue layers, it is nonetheless already well equipped to develop means of facing this challenge. The polyp is like a balloon that lets water in as its inner cavity is expended. What it needs to expel this water out is simply to contract this cavity, to reduce its volume. Cells have for a very long time discovered the secrets of movement. The incredible force of the motor proteins has already been harnessed by them, allowing the transport of substances throughout these miniature cities but also enabling them to contract their outer wall or even change their shape, something necessary for it to be divided during reproduction. The motile cells also learned ways to build large bundles of such moving hands to create a means of propulsion and direction for their whole body. This capacity nonetheless remained mostly limited to individual cells after the emergence of animals. The extremely slow and small movements of the sponges are very limited, due to the lack of cohesion between its whole and its parts. The polyp, on the other hand, is made of densely packed cells, layered according to their nature and the role they play in the life of the creature. As countless of them are mercilessly selected for their ability to endure the rough conditions of life to which they are subjected, they are therefore heavily pushed to discover ways of controlling the shape of their body. As mentioned before, they first need this in order to stand up and be able to point their mouth upward, where it will be able to collect its tribute from the sea, but they also need it to contract and expand their gut, letting water in and out, according to their need to ingest food or excrete wastes. The result of such severe selection will be the discovery of muscle cells and tissue.

A muscle cell is not fundamentally different than any other, which all share an ability to contract and relax through the association of the work of motor proteins, with networks of filaments pervading their body. It nonetheless arose as the result of a selection favoring a certain efficiency with this task, allied with a capacity to form strong bonds with other cells of the same kind. Its shape was also refined, made more cylindrical so that large bun-

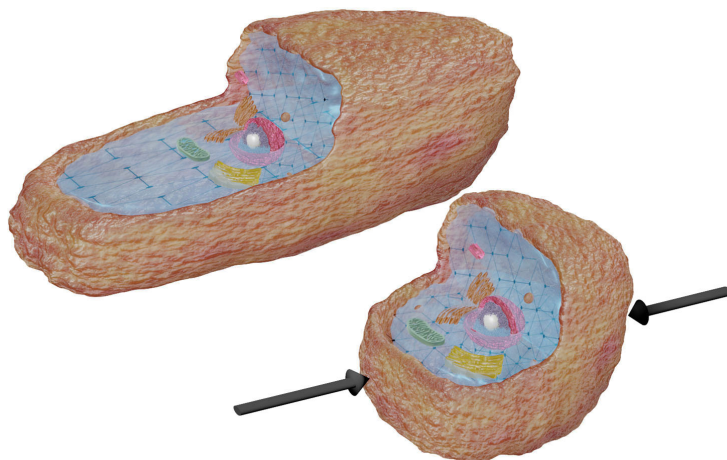


Figure 15.2: *A muscle cell, in a relaxed and contracted state.*

dles of them could be formed without any waste of space. Robustly tied to one another, arrayed according to the needs of the living thing to which they belong, these cells can then work together toward the same goal, joining their forces and moving in harmony. Their movements are focused on one axis, forming a line that can be contracted or extended, following signals received by each one of them (See Fig. 15.2). Through this ingenious organization, the force of the motor proteins of each cell can be coupled with the one of all the others and directed in a single direction. This is how animals discovered a way to extend the mobility of the machinery of the cells to set in motion entire tissues, and thereby also allow a creature made of trillions of cells to move its entire body. When muscle tissues are present on a sufficiently broad part of the creature's body, the linear movement of the motor proteins inside the muscle cells can be transformed into a three-dimensional one, with large creatures potentially able to move as freely as the motile cells equipped with their beating tail.

For now, the polyp is nonetheless securely anchored on the earth, like a child holding on to its mother for safety, even though it can make use of its newfound ability. The muscles pervading its outer layer are used to move the tentacles around its mouth, like little arms helping it to bring food into its mouth. The muscle belt surrounding its gut also finally allows a fine control of the flow of water in and out of it. When it contracts this muscle belt, water

flows out of its mouth, carrying with it the waste that it has no use of. When it relaxes, water flows in, bringing food in. Since it has no skeleton, this living thing heavily relies on the sea itself to shape and support its own body. As it traps water inside its gut, the pressure exerted by the liquid both inside and outside of the creature indeed provides natural support, relieving the muscles of a part of this task.

The creature has now passed a milestone, one that marks its unmistakable belonging to the animal kingdom. Contrary to a sponge, the fleshy aspect and relatively rapid movements of the polyp indeed immediately dispel any doubt of the observer concerning its nature. A feat has been performed by the humble living thing, which has extended the benefit of a more active behavior discovered long ago by the motile cell to a complex and large form of life. It nonetheless also goes further than its lilliputian predecessors, as it also takes advantage of the unique gifts bestowed to the massive living things. The growth of this organism will be bounded by the limits of the population of the lesser forms of life feeding it, and the availability of a sufficient source of energy like oxygen, rather than the structural constraints of individual cells. Its lifespan will not be limited by the one of any of its cells, which are all potentially replaceable. Its fate now partly is in the hands of the larger forces of nature. The earth provides the stability and support it needs, while the sea feeds it, but both of them also shape it like a couple of potters manipulating a clay vessel. Their fingers apply pressure on it, a pressure spread across millions of years and myriads of individuals, smashing the imperfect ones to pieces and reproducing the most impeccable specimens in great numbers.

In their infinite patience, the earth, the sea, and life itself therefore polish their creation, adding extremely minute changes with the passing of each generation, not only changing its appearance but also carefully devising its life-plan, the plan contained in the library of the seed-cell and which defines the entire lifespan of the future animal that it will become, unless external forces stand in the way. From a single seed-cell, fruit of the loving encounter of the essence of two other beings, a cell that has taken roots on the rocky floor of the sea after being marooned and carried by the hands of the sea to be gently deposited on the skin of the earth, it has grown into a vivacious polyp, moving its tentacles like tiny fingers and contracting its muscular body. This, however, is only the

first stage of its life. The forces of nature indeed have with great care pressured its ancestors so that it would now be able to take advantage of the chances offered to it by the rest of its life-plan.

Steadily fed by the sea, the polyp not only grows but also undergoes a deep transformation of its nature, one that is inscribed in its life-plan, patiently being unfolded. Rings begin to appear on its skin, as its body is torn from the inside, with parts of it cleaved into new horizontal layers. As time passes, it resembles less and less to a water-containing vessel and more to a stack of irregularly shaped disks, with roundly shaped protuberances instead of functional tentacles. Satiated by the wealth of the sea brought into its mouth by the currents, the creature has gained sufficient strength to kindle the desire to give birth to new beings. Chained to the earth, it is nonetheless incapable of searching for a lover with which it could share its essence to give birth to a new and unique individual. What allowed it to grow until now, its anchorage to the earth that allowed it to extract tribute from the soldiers of the sea, is now a burden, a stumbling block in the way of its instinct to reproduce. The creature is nonetheless resourceful. The intelligence of life works for its evolution, selecting those that explore the right paths. The wisdom of the cells is rediscovered and put to use, and in particular its capacity to divide itself. Strong and filled with nutrients and energy, the polyp therefore prepares to cleave itself, but unlike a lone cell, it will do so several times at once. Each disk of the living stack that it now forms represents a future independent living thing, which will share its own essence, an almost exact duplicate of its library of information defining its nature, as well as its life-plan.

Once the metamorphosis of a living disk is complete, having developed the means to live on its own, without the help and strength of its parent, it suddenly makes use of its muscles to extract itself from its non-fully formed sibling below it and elevates itself as the contractions of its muscles give it the shape of a flattened bell. The young child of the creature that allied itself with the earth to receive the wealth of the sea is therefore set onto a different path than the one of its parent, one that was discovered by its ancestors and inscribed in the library of information of their descendants. The destiny of the young animal, not set in stone but rather in the chains of bases at the heart of each one of its cells, is to forsake the alliance formed by its parent with the earth, which

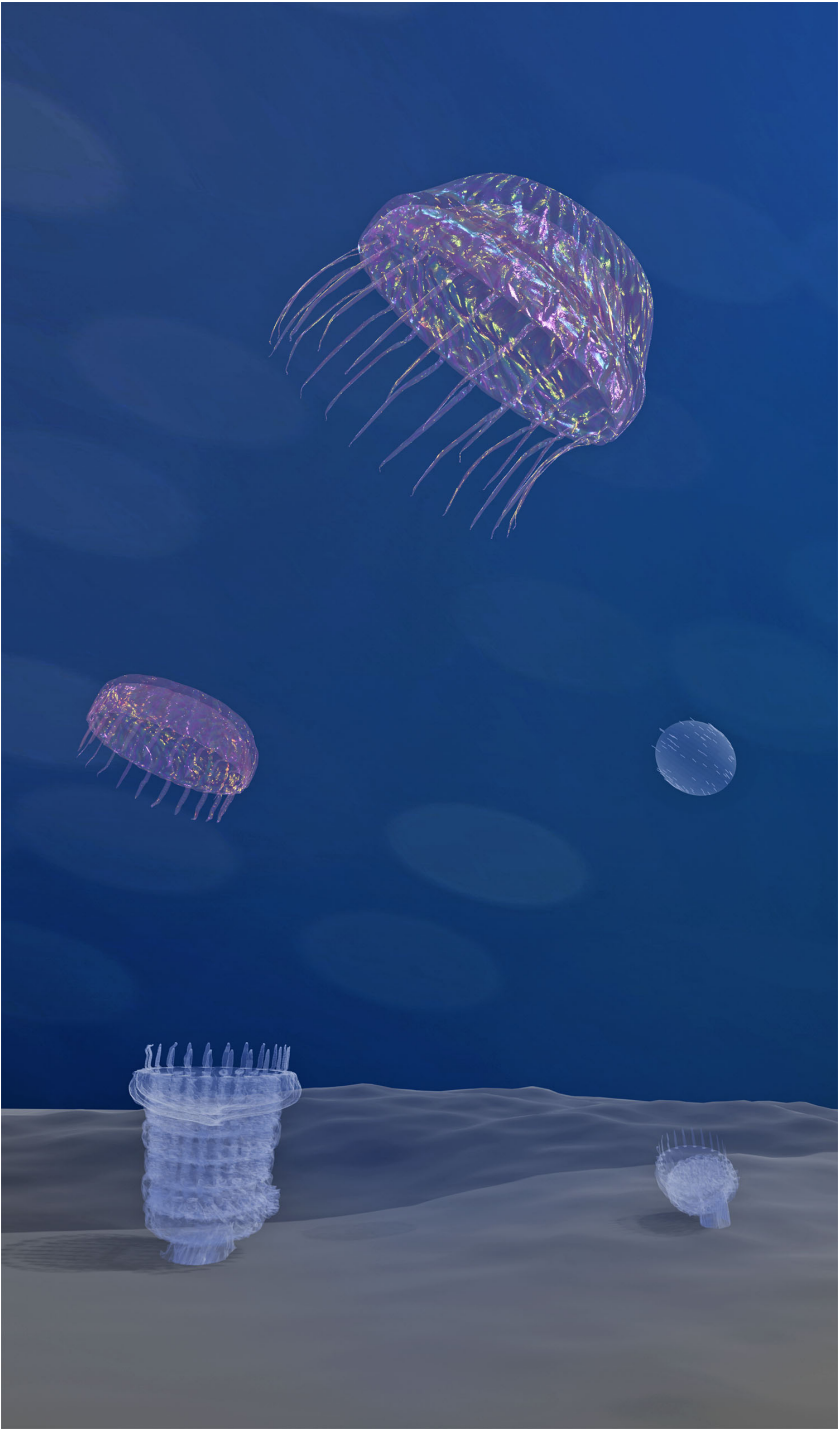


Figure 15.3: *The life cycle of a jellyfish.*

was always meant to be temporary. Its flexible body, pervaded with thin muscle tissues, indeed renders it able to actively search for what it needs instead of just waiting for it to come. It is no longer a trap for food but a hunter, roaming the sea, moved by its hunger for nutrients or its lust for a lover. The polyp was a babe fed with the milk of the sea, building up its forces and waiting for the time of independence, and once the moment of liberation comes, it departs from the motherly breast, ready to feed on a more nutritious food and prey on forms of life weaker than itself. The creature becomes a jellyfish as it continues to grow, in the shape of a bell with long tentacles.

Having abandoned the earth, the jellyfish enjoys a greater degree of freedom. Without any attachment, it can explore the vastness of the ocean, tumbling and swimming according to its whims, contracting its body and waving its tentacles. This freedom nonetheless comes at a cost. As a far greater amount of energy and nutrients are spent on feeding the muscles that allow the animal to explore the deep, it needs to be more efficient in the way it acquires them. The jellyfish are therefore ruthlessly selected so that they would improve such traits. Their muscle mass therefore increases, and the size of their gut is reduced in proportion to the rest of the body (See Fig. 15.4). Tentacles grow longer, thinner, and more agile. Having renounced the stability of the seafloor, it now finds itself master of its own orientation. It is no longer bound to stand up, erect upon the earth and pointing upward, toward the surface and the sky beyond it. It develops a greater intimacy with the ocean as it plays with its currents, at times letting itself be carried by them but at others also resisting their push and going against their flow, when they oppose the satisfaction of its hunger and lust. Adulthood, however, is not only the age of freedom. It also involves a heavy responsibility, which is sexual reproduction.

The jellyfish can be seen as the offspring of a polyp rather than a mere adult version of it, as the latter divided into several individuals. These nonetheless shared the same essence, an almost identical library of information, differing from one another only by a few scribal mistakes. Contrary to its parent, this second generation is nonetheless composed of individuals able to actively search for a mate among a population of the other sex, and it thereby benefits from the accelerated evolution offered by the shuffling and combining of the libraries of information of two different individu-

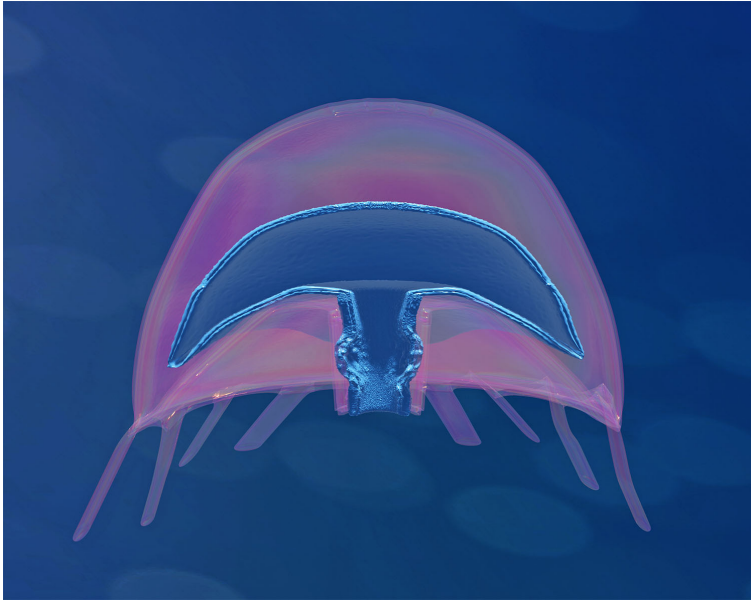


Figure 15.4: *Frontal cut of a jellyfish, with the inner layer in blue and the outer layer translucent.*

als. The result of the loving encounter of the complementary sexes will be a new seed-cell, but one that will reproduce the life-plan that began one generation earlier, with their own parents, as this seed will fall on the rocky floor of the ocean and soon anchor itself to it, before becoming a polyp, starting a new cycle.

The emergence of such a complex and elegant life-plan is nonetheless only the result of the fact that the complementarity between the polyp and the jellyfish provided an edge to this species compared to its competitors. One possibility is that this great disparity of lifestyle between the two kinds of creatures allows them to avoid a self-destructive behavior, where the young and the old compete for the same resource, the same space, thereby striving against their own kind and killing their own “bloodline.” The polyps occupy the floor and feed on the living matter suspended in the water, while the dominion of the jellyfish is the body of the sea, where it can hunt larger living things. The beauty of its elaborate life-plan resides in its combination of the strengths of the earth with those of the sea, security and freedom, sessility and mobility, division and love. This allowed such creatures to survive in places

where the sponges were decimated, and paved the way for a rapid evolution that would allow some of their distant descendants or close cousins to reign over all the living things filling the sea.

A decisive advantage offered by the sexual nature of the jellyfish is the fact that the competition for mates considerably enhances the selection pressure exerted on them. It stimulates the play of love and war and this, in turn, further accelerates the rate of new discoveries by this branch of the tree of life and its evolution. The arms race between members of the same sex that was initiated soon after the discovery of sex by lone cells is now extended to entire animals, something that may lead to the emergence of physical disparities between male and female animals, as both sexes will be subjected to pressures of a different nature, linked with the role they play in the perpetuation of their kind. These new animals will nonetheless also need to considerably develop one of their nascent abilities, which will be crucial to assert their dominion over the sea and other forms of life: a capacity to sense their environment and react accordingly.

Re-flection: The Muscles Within Us

The play of attraction and repulsion rules over the earth and all that stands upon it, enrapturing bits of matter to form a tornado, continuously dancing under the skies. Life began as a manifestation of this play, with chains of bases replicating themselves, taking hold of dead, earthly matter and bewitching it, turning death into life, earth into fire. Slowly, life began to investigate the nature of this play and began to discover its secrets.

Balancing attraction and repulsion, life learned how to exploit their contrast to produce motion. Molecular servants of the cells attached and detached themselves on long filaments, as the tumult inside the wall pushed them and allowed them to progress on these miniature roads. The mastery of motion was soon extended beyond the walls of the cell, with beating tails used to swim, using the same secret, exploiting an alternation between attraction and repulsion of bits of matter.

Extending our arms in front of us, flexing our fingers one by one in a wave-like motion, we are the witnesses of the wondrous work of a multitude of muscle cells, and of their diligent servants. These cells have been shaped to contract and extend themselves when appropriately stimulated, combining the work of countless molecular actors of the play of attraction and repulsion. They turn the attraction and binding of these workers onto filaments into a contraction movement, whereas the end of such attraction leads to a parting away and a relaxation of the cell.

Our arms and legs are moved by our will, while the muscles of our heart and chest are driven by instincts, but they all are large-scale manifestations of a multitude of infinitely small dances between atoms. Striving to find an equilibrium between the forces tearing them apart, each molecule seeks partners, desperately binding itself to those having complementary surpluses or lacks, and keeping others at bay. Our back is supported by this play and the work of these impassible laborers of life, and we stand because of their commitment to the mission for which they were mercilessly selected.

We have inherited part of our nature from the first animals having discovered muscles tissues, the polyps standing on the rocks of the seafloor, and the jellyfish swimming in the oceans. When

we inspire and let fresh air fill our chest or let food or liquid pass through our mouth, it is because these animals found a way to harness the strength of muscle cells to move an entire body. We also are vessels, jugs in which fluids are poured under the action of our girdle of muscles, allowing us to extract a tribute from our surroundings, before emptying ourselves by contracting our chest.

Weaving muscle fibers and judiciously arraying them all around the body, life expertly plays with matter, prodigiously harnessing the power of patterns of attraction and repulsion of atoms to produce movement. The linear motion of the molecular workers of our cells is turned into three-dimensional exploration, allowing a colossal mass of cells to appropriate the sea or the air, to seek rather than merely wait.

As we walk over the earth, swim in the sea, hold objects in our hands or people in our arms, we may remember that our body may obey our will but that without the myriad of molecular workers, patient actors of the play of attraction and repulsion, we would remain as still as a stone. Their work is nonetheless itself only a manifestation of the very fabric of the universe, as this fabric sets the rules of the play, and its perfection is what allows the burning of the fire of life.

Chapter 16

Sensing Body: Nerve Networks

One of the defining features of life is its unique ability to not simply let itself be passively shaped by the commotion of the universe, as all parts of the earth and the sky are, but also actively interact with the forces of nature, and the whole of the creation, even though one should keep in mind the fact that this distinction remains somewhat arbitrary, as the fire of life is a phenomenon that appears to arise as a mere peculiar manifestation of the same play of attraction and repulsion ruling all that belong to the earth or the sky, with not objective separation between what is living and what is dead. This being said, the animal kingdom certainly is the branch of life having the most zealously embraced this role of actor of the play of nature, with its members ceasing to be mere pawns. As always with life, the wondrous reactivity of the animals nonetheless is the fruit of an extremely long and strenuous work, billions of years in the making before this fruit became ripe enough to be plucked by our distant ancestors roaming the depths of the seas.

As seen earlier,¹ lone cells developed primitive ways to detect properties of their environment, such as receptors sensitive to the presence of particular substances in their vicinity or contact with food, for example. The walls of the city-cells are lined with gates that open when different conditions are met. Some of

¹See Ch. 1.13.

them bow to physical pressure exerted on them, while others are unlocked when a chemical key is inserted into them, a molecule whose shape causes the gate to change its shape through the appearance of an imbalance in the play of attraction and repulsion between its atoms. Others may also take an active part in the play of attraction and repulsion that takes place between the substances found on the two sides of the wall of the city-cell. They may exacerbate tensions between the two environments, closing themselves up and thereby preventing the reaching of an equilibrium through the pairing of elements and molecules having either an excess or a lack of bonding force, but they may also facilitate the reaching of such an equilibrium, if the conditions tied to their own nature are satisfied. The development of these primitive sensing mechanisms would soon prove itself to be crucial for the evolution of animals.

As animals, such as the jellyfish examined in the previous chapter, began to abandon the secure and stable soil of the sea-floor, the hard earth, to enjoy the freedom and opportunities offered by a more adventurous life in the flow of the sea, they were immediately subjected to a considerable selection pressure. As free-swimming creatures, they indeed constantly faced the need to actively interact with the things surrounding them, and to adequately react to these encounters. Contrary to the sponges, fed by the currents, they need to be able to locate food sources. They need to be able to orient themselves so that they would not get lost in the sterile abysses of the sea and instead find their way upward, toward the shining orb that radiates through the surface of the waters and feeds the light-workers that will, in turn, feed the larger creatures of the sea. They also need to minimize violent collisions with the rocky earth, which may damage their bodies, and to identify predators that may intend to devour their flesh. As a result of this pressure, those endowed with particularly responsive and sensitive cells under their skin, inducing live-saving reactions of the whole creature, reproduced in greater numbers and soon replaced those that did not receive such a gift. New types of specialized cells thus emerged in their body, whose sole purpose is the identification of certain stimuli, coming from the creature's environment in particular. They are commonly known as *neurons*, nerve cells.

The sensing cells making the bulk of our brain are very similar to those that appeared in the first free-swimming animals. They

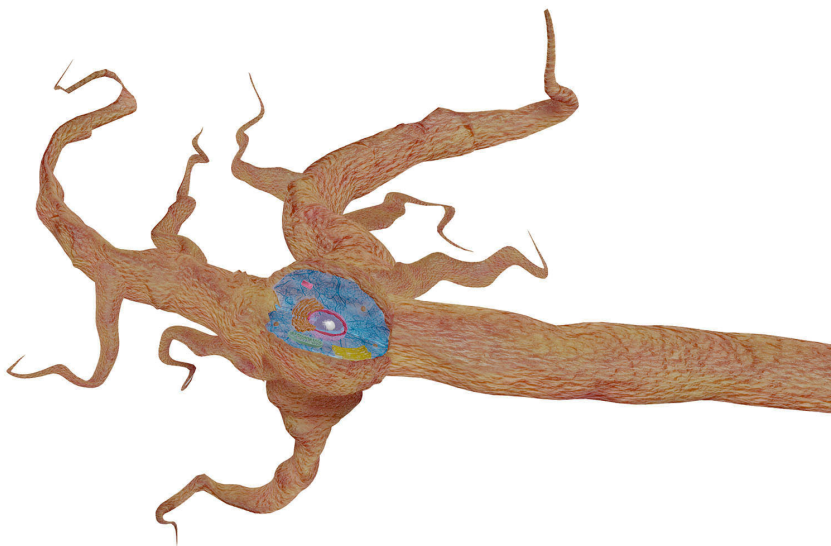


Figure 16.1: *Part of a sensing cell, a neuron.*

resemble other types of cells, with a core, a library of information at its center, and all the machinery necessary for it to function, but contrary to other types of cells, they have a series of protuberances of various sizes on all sides. Most of them represent sensors that gather information concerning the ways by which the earth, the sea, the sky, or other parts of life interact with the individual to which the cell belongs. Like miniature wires, they carry these pieces of information in the form of an electrical tension, that is, an imbalance between bits of matter that are either in lack or have an excess of a certain force and therefore exert a pressure to find a complementary partner, one that would lead to the reaching of an equilibrium, solving these imbalances. Eons before mankind discovered the usefulness of such tensions, life ingeniously exploited them. The tension, this inner strife between atoms and molecules, is indeed extended by the cell through a longer protuberance, one that can be considerably longer than the rest of its body, and is used to communicate a signal announcing the detection of a stimulus to other cells, as a stretched string of a bow is used to propel an arrow across long distances. These cells can be other nerve cells, but they can also be of a different type, such as muscle cells.

The first nerve cells were in all likelihood organized in very

diffuse networks, entrenched in the skin of the entire animal. One of the most rudimentary and fundamental uses of such a nerve network would have been to detect pressure on the skin, that is, contact with matter, other than the waters in which it was plunged. By connecting this network serving as an array of switches directly to bundles of muscle cells, the creature may exhibit a primitive and impulsive response to an encounter, with either a part of the earth or another living thing. As each individual is endowed with a unique pattern of such nerves, found in different quantities and arrayed according to different configurations, a selection then occurs. Out of the relatively random set of responses to such encounters, the individuals whose reaction helps them to survive and reproduce soon begin to out-breed and replace those whose reaction is less efficient. Patterns of behavior then emerge, which at this stage are probably almost exclusively innate. If a small thing touches the tentacles near its mouth, the animal will try to ingest it. If something touches its body, a swimming reaction may be triggered to evade a potential danger (See Fig. 16.2).

As the strife between individual animals and the combat between them on the one hand and death itself on the other continues, the fittest have a more numerous descendance, and these often are the creatures having the fastest and most adequate reactions to an increasingly wider range of stimuli. They can now begin to touch, to smell, to perceive the radiance of the sun and the coldness of the deep, with each one of these parameters becoming a new dimension in which the living thing is thrown, even though it has yet to become aware of this fact. The larger and denser the network of nerve cells is, the more finely can the reactions associated with the information gathered by the creature be tuned, mostly through selection, and as a result of this the individuals having larger concentrations of neurons where they are most needed, near the mouth in particular, are greatly favored. The diffuse network begins to exhibit larger masses of nerve tissue at the front of the body, allowing a more efficient and precise processing of the stimuli coming from what begins to resemble a head.

The network of tensions forming the nervous tissue of the animal soon grows to an incredible level of intricacy. It forms an extremely complex and delicate grid made of millions of cells, with each one of them potentially connected to hundreds of others. This remarkable edifice, already present in some of the earliest and most

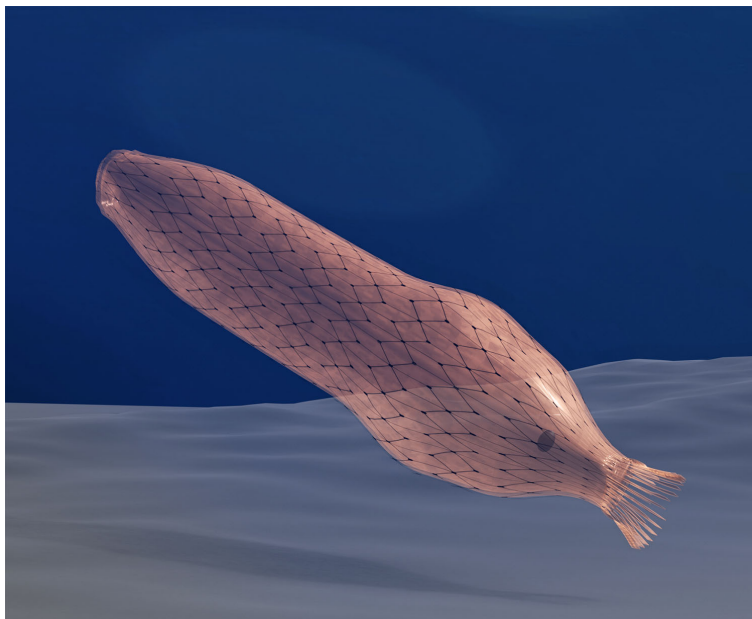


Figure 16.2: *Representation of a primitive free-swimming animal (Similar to the branch Sipuncula), with a diffuse nerve network and a neuron concentration near its mouth.*

rudimentary animals, is a true feat of life. Each connection represents a stretched string which can be plucked by one of the cells at its extremities, a part of the gigantic play of attraction and repulsion between chemical substances found in this mass of cells, with the entire structure playing a brilliantly composed melody, made of billions of notes played simultaneously and yet producing a perfectly harmonious response of the body, which dances to this tune to which it is familiar. This labyrinth of living tunnels and gates is very earthly, that is, made of matter coming from the body of the earth and then integrated to life, but it also forms the basis for something that stands on top of the earth, something that transcends its pure materiality.

In the same manner as the long chains of bases ignited the fire of life and now sustains it, the nerve networks open up a new space, an abstract one, which even though they stand upon an earthly basis, cannot be touched or experienced directly with the senses. The chains of bases represent a library of information encoded as long lines written with molecules used like the characters

of a natural language, information that is inscribed on an earthly support, matter, but whose value and signification goes beyond it. Every piece of this library bears a signification that is only expressed once it is used to produce a new living thing and unfold its life-plan. The nerve net of the animals represents a similar space. Each gate, each condition for their opening, each connection with other cells, and each substance that these will let flow out once they are opened, all represent different dimensions of this new space that is used, albeit unknowingly, by the animal to gain an edge over death and over other forms of life competing with it for the wealth of the ocean. The library of information at the heart of each cell, including nerve cells themselves, is written like a living book, as long two-dimensional lines written with only four different characters, folded in three dimensions and forming secondary and tertiary structures that also bear a signification. The neural space, on the other hand, is an edifice with an even more complex structure.

A nerve network is extended across the three spatial dimensions, but contrary to the library of information of the cells, it also fully occupies the fourth dimension: time. The different types of neurons, and the various ways by which they interact with one another, can nonetheless also be interpreted as distinct dimensions of the neural space, as these parameters considerably increase the range of information that this space can contain. The melody played by this circuitous instrument represents an elaborate pattern of connections, substances, tensions, and coordination that are supported by the earthly nature of the instrument, but nonetheless also represents something more, as each melody is not random, but rather the fruit of a dual process of experimentation and selection. As it was the case with the chain of bases, with which meaning emerged out of randomness through the wondrous alliance of mutation and selection, meaning once more emerges out of meaninglessness, this time in the neural space of animals. A prodigious number of patterns were meticulously tested by each individual, during each instant of their lives, exploiting the entirety of the spectrum of expression offered by the network, and if these induced patterns of behavior were beneficial to the survival and reproduction of the individual, they were favored and slowly became prominent in the population of this particular kind of creature. The animal may have no notion of the content of its

neural space, and of the meaning of the patterns expressed within its boundaries, but meaning nonetheless emerges within this space, which is supported by his own body. As a population, this branch of life soon discovers patterns useful to their kind. Some may cause an individual to detect the presence of a particular predator, while others may allow him to find a life-saving food source. Knowledge therefore begins to be accumulated by the animals, at this stage not passed on as a culture that is taught by parents and learned by children, but rather innate, passed on inside the other space upon which its whole being rests: the library of information at the heart of the reproductive cells. The configuration of the network, the wiring of this gigantic instrument composed of billions of strings in tension that determines a large part of the melodies setting the animal in motion, therefore represents an inverted pyramid, a monumental edifice standing on its smallest and oldest part, the foundation stone of all life.

As the net grows in size and convolution, the patterns painted in the neural space become increasingly refined. What had been until now mere reflexes, almost mechanical reactions triggered by nerve cells, slowly become sophisticated patterns of behavior, not the result of a learning process but rather the fruit of the hard-wiring of their neural instrument or, in other words, an instinct. Led by these instincts, carved into the very essence of his being, the animal does not need to “know,” he just does, because out of the random behaviors of his ancestors, the patterns of behavior that were the most appropriate to face this particular situation were selected by life itself, and the descendants of those equipped with these valuable patterns replaced those who had not this chance. The animal bears upon his body the weight of the knowledge contained within his neural space, and his instinct leads him to make use of it, but he has yet to develop a mind allowing him to become conscious of its existence and explore it. This unknowing carrier and supporter of this emerging, unconscious form of knowledge, this new storehouse of wisdom, nonetheless immediately benefits from this new meta-physical realm, as it allows the creature to lift up the veil that until now covered most of the earth, the sea, and the sky. Like a potter shaping a piece of clay, the forces of nature shaped the neural space of the animals, favoring the individuals who would be able to develop a certain openness to the discovery of nature, those who would be the most sensitive to its

signs, its language, and the most able to represent the earth, the sea, and the rest of life with their neural space, that now becomes their *world*. The primitive animals will never become aware of the nature of this world standing upon and out of the earth, of the material realm, but they will nonetheless live prisoner of it, and all that they will know of the earth, the sea, the sky, and the life between them will be through the lens of this space, of this world.

A crucial property of the world, understood in the sense of the sum of all the representations found within the neural space, which distinguishes it from the library of information of the cells in particular, is the fact that it is in continuous movement, with new connections and new patterns constantly emerging and fading away, according to the needs of the individual. A large part of the basic structure of the network will be passed on from parent to offspring, through the library of information of the reproductive cells, but the world opened up by this neural network can also be built up by the living thing dwelling it, with each nerve serving as a doorway between earth and world, a passage between the experience and the representation, the material and the meta-physical. As the animal explores an area of the sea with his senses, using the extremities of nerve cells as sensors, he can draw new patterns within the neural space that will be preserved inside it, thereby building up his own world, creating crude representations of the infinite complexity of his environment that will allow him to win the war he is waging against death and the other forms of life.

The animal therefore learns. He builds up his world, the space opened up by his nerve network, through his embodied life experience as he roams the sea in search of food, safety, or a mate. When a loving encounter occurs and his seed gives birth to another living being, the knowledge accumulated during his life, the parts of the world that he built by himself, is nonetheless not passed on to the new generation and it will crumble when he departs from life to re-join the great body of death. Only the innate structure and nature of the network, that is, the neural space and the hard-wired patterns contained within it at birth and built from plans contained in the library of information of the seed-cell, will be transmitted to his children. Learning at this stage of the evolution of animals is therefore only of secondary importance. The driving force of the growth of the whole of the tree of life remains the play of mutation and selection, creation and destruction, love and war.

New generations of animals therefore always need to rediscover the earth and the sea, and build their own world, but they received in inheritance an increasingly fitter ground, a stronger and wider foundation upon which they will edify their kingdom. The very dimensions of this space, this world, will be adjusted according to their needs and their relationship with the earth and the sea, by adjusting the complexity of the nerve network. The movement of evolution of this world will therefore not always be one of continuous expansion and complexification. This space will sometimes be contracted, even losing dimensions that would have lost their relevance. Some animals, for example, developed ways to perceive the magnetic field of the earth. This opened a new dimension of the earth to them, which was brought into their world as they mapped this field with their senses and used this map for navigation, among other potential uses. When better ways to perform such tasks, using vision for example, were discovered, the information gathered in this dimension lost their relevance to some of these living things, and individuals not wasting their own resources to exploit this now useless knowledge were then favored and selected. The world of the living is therefore intimately linked with the relationship that they have with nature. Animals seize every chance they get to survive and better themselves, every helping hand offered by the earth, the sea, or the sky. When they are blind and lost, the earth can guide them with the field produced by the rivers of iron flowing at its core. When they grow more acquainted with the envoys of the sun, they will then use the sky for guidance, their bodies reflecting this new allegiance. Just like their body, their world therefore reflects their relationship with the forces surrounding them, with changes that are not limited to the content of this world but also include the very space in which it is built, and even the number of its dimensions.

Furthermore, there is another dimension of the animal world, one that appears unique to this branch of the tree of life and that plays a crucial role in its evolutionary success. This dimension is intimately linked with the earth, the sea, the sky, and life, that is, the physical realm, but it nonetheless does not reflect one of its inherent properties. It rather is rooted in the world itself, and in the imperative of life to strive for its survival and reproduction. This dimension is one of instinctual valuation of the world, associating each thing with a particular linear spectrum of sensations, with

one extremity known as “pain” and the other as “pleasure,” and various shades of both in between. This way of seeing all things as potential sources of pain or pleasure is an incredibly powerful mechanism, a driving force for the evolution of animals. It acts as a sort of instinctual guidance, carved inside the very core of the living thing, that has emerged as a system rewarding the creature for performing an action that would be beneficial to its survival and reproduction, and punish it for an act that would either endanger its body and therefore hinder its capacity to father an offspring. It is based on specialized neurons placed all over the body, in various densities, and it is these cells that trigger a feeling of either pain or pleasure, and physical reactions associated with both. The living thing takes no decisions in this matter, and the cleaving of the world between the painful and the enjoyable is at this stage almost entirely determined at birth, by the very structure of the neural space built according to the plan found in the library of information of its seed-cell. When the animal is hurt in his flesh, pain is felt and reflexes cause the body to contract its muscles, often to evade the threat. When mating occurs, it can be supposed that the act may be pleasurable in the more primitive animals as it is when performed by men and women, although this is almost impossible to determine with certainty.

The extraordinary power of the instinctual guidance of pain and pleasure can be seen as a higher order of manifestation of the play of attraction and repulsion, affinity and strife, love and war, one that occupies an important place within the animals’ world and finds its roots at the core of the nervous network, spread between earth and world. Pleasure is the reward of love, pain the price of war. The first is to be sought after and the latter avoided. The behavior of the animal is ruled by this play of antagonistic forces, and the elements of its behavior that come as responses of the information gathered by its nerve network, its senses, will support and enhance the innate driving force that leads it to strive to survive, avoid death, and find a mate to give birth to a new generation, whose members will stand on the shoulders of their parents. The goal of life thus remains unchanged. Every new space opened through the evolution of life, every new layer of the play of complementary forces, only fortifies life and helps it reach the goal that it is destined to tend toward. The animals’ world will soon become one of the grandest territories where the tension between

attraction and repulsion, pain and pleasure, love and war will be displayed and manifested. A phenomenal palette of behaviors will emerge, as each individual animal will attempt to build its own world, fruit of its own experience of the earth and the sea, and the most skillful builders will be rewarded with a plentiful descendance. The earthly foundation of this world is nonetheless at this point in evolution only emerging. It will continue to grow and change, increasing the range of what the dwellers of this world will be able to build in it. This being said, the nerve network and the world standing upon it will not supersede the movement of evolution of the rest of the body. The entirety of the animal continues to strive for life, and its whole body continues to be shaped by this battle and by the forces of nature.

Re-flection: The Nerves Within Us

Relieved of the necessity to seek food and to reproduce, the parts are cared for by the whole, and their talents can be nurtured as they discover that they can play a unique role in the body. The most exposed to the air and the waters will serve as ramparts of the flesh, but the presence of scouts and guards near these will offer a crucial advantage to the organism.

Cells early-on sensed the presence of substances in contact with receptors in their wall, but animals can now develop entire classes of cells devoted to the perception of the creation. The astonishing richness of the earth, the sea, life, and the sky is within their reach, and all they have to do is attune their body to allow it to understand the language of nature.

Gently placing a hand on an object around us, we feel because of the agency of sensing cells. The pressure exerted by the weight of our limb on the earthly thing triggers some of them, offering us information concerning the texture and the hardness of what we touch. Simultaneously, others tell us if this part of the earth in contact with us is warm or cold.

Each time we open up the doors of our perception, a flow of information is unleashed. Its source is found all around our body, and it runs at lightning speed, filling up our mind. Information is turned into representation by our brain, thereby entering our world, as the earth, life, and the skies are unveiled to us, shining as impulses within our nerves.

This network of nerves pervading our entire flesh is the doorway between earth and world. It is through this network that we can make sense of our surroundings and interact with them. It is the fruit of a considerably lengthy work of experimentation and selection by life, where each pattern of wiring of nerves helped our predecessors to survive and reproduce.

Standing upon the earth, supported by this network of living gates and this labyrinth of wires, our world transcends our earthly nature, allowing the representation of all things imaginable. When we remember the wildest creations of our mind, they are nowhere to be found in nature, but they are present in this realm that is supported by the earth but stands out of it.

Through the work of our senses, our world is nonetheless deeply rooted in the earth and the sky, and conversely, our flesh has been profoundly shaped by the flow of nature poured into our world. Our eyes, sensing the presence of the sun's brilliance, are closer to the sky than to the earth, as only if they are wisely located can they improve our chances to survive and father children. It is because their flow of information was found useful that they remained part of our body, as it allowed our ancestors to distinguish up and down, night from day, even before they could truly see.

Taking a prickly object into our hand, we may also experience a particular dimension of our world, one that does not reflect an inherent property of the earth, life, or the skies, but rather represents a purely worldly guidance that emerged naturally during our evolution. Pressing the thorny thing onto our skin, we feel pain and instinctively take it away. Thinking about eating a succulent dish or performing the ritual of love with a beloved, our mind feels pleasure, which is reverberated through our flesh, tingling our skin.

Pleasure and pain are a way for life to invite us to participate in the play of love and war, cleaving our entire world, the earth, life, and the skies in two: the attractive and the repulsive. We are driven by our deepest instinct to avoid pain and seek pleasure, of the flesh or the mind, and this is why we, often unknowingly, devote our lives to the great play that drives life. What is delicious to our palate is what contains what we need the most for our body to survive, and we likewise consecrate a significant part of our existence to satisfy the lust of our loins, as the pleasure it gives us is our reward for fulfilling our duty of extending our bloodline.

We may now reflect on the most painful and pleasurable experiences of our life, and ponder the relation between them and the play of affinity and strife, love and war. How do our senses influence what we think, what we value, and what we seek in our life? Should we simply let ourselves be guided by their flow, or should we try to overcome the current?

Chapter 17

Life with a Direction: Bilaterality, Polarity and Cephalization

As seen in the previous pages, the severance of the animals' anchorage on the seafloor has profound repercussions upon their evolution. Their flesh is then swiftly shaped by their new life as free-swimming creatures roaming the shallow waters as well as the depths, traveling through the paths of the oceans, exploring and conquering a large part of the face of the planet. It leads to an elongation of the body, as those exhibiting such features probably were more efficient at navigating the seas, and thus were positively selected over those who did not. It also leads to the emergence of concentrations of nervous tissue near the mouth, where the animal has a greater need for its sensory perception to feed and find a mate. This evolutionary movement nonetheless continues together with the ruthless selection operated by nature itself. The animals are patiently refined by life, with each kind and each individual striving to gain the resources needed for their survival and reproduction, pitted against one another so that the fittest would prevail and transmit his gifts to a new generation.

By gaining their freedom from the body of the earth, the soil, and accepting the burden that comes with this freedom, such as a lack of stability and reference point, the animals were forced to develop their senses. This sense perception, in turn, lifted up a veil

covering the world around them. They now had to find their own reference points in their environment, and they thus discovered some of the largest forces of nature, and their arrangement. They now stumble upon the surface marking the boundary of the sky and the air when they go up, and collide with the rigid body of the earth when they go down. Their movements are mainly linear, forming a curved line traced across the four dimensions opened up by the space formed by the sea, and their flesh thus has a front and a back. The animal's life is then given a series of directions and a polarization, and these will continue to shape his body, across millions of generations.

One of the most fundamental and long-lasting changes that occurred at this stage of the evolution of the animal branch of the tree of life certainly is the emergence of a linear digestive tract, with a mouth at the front of the creature, where food is ingested, and an anus at its back, where waste is excreted (See Fig. 17.1). Before, a single opening served both purposes. This implied that the two actions could hardly be performed at the same time, and that feeding had to be interrupted to get rid of the accumulated waste that could not be digested. Now that the creature has been transformed, ceasing to adopt the form of a vessel and now becoming a tube, with the digestive tract forming its inner surface, the processing of food can now be continuous. There is no longer a need to be able to distinguish what is left to be digested from what should be excreted through the single opening, as the food is slowly processed and the waste excreted in a single, fluid movement. This movement also follows the general trajectory of the animal itself, as it swims through the ocean. It moves in the water with its mouth facing forward, where potential food will be found and engulfed, while excrements are left behind, to fertilize the seafloor, seldom entering into contact with the skin of the creature, something that may encourage the proliferation of smaller living things, like bacteria, upon it, which may in turn become a burden or a threat to the animal.

Animals with such tubular shape and elongated bodies are the first worms, and even though they now represent some of the most primitive animals, they at the time of their emergence were some of the most complex and efficient creatures of the middle realm. Their tubular form is developed relatively early after the performance of the ritual of love, as the creature grows following

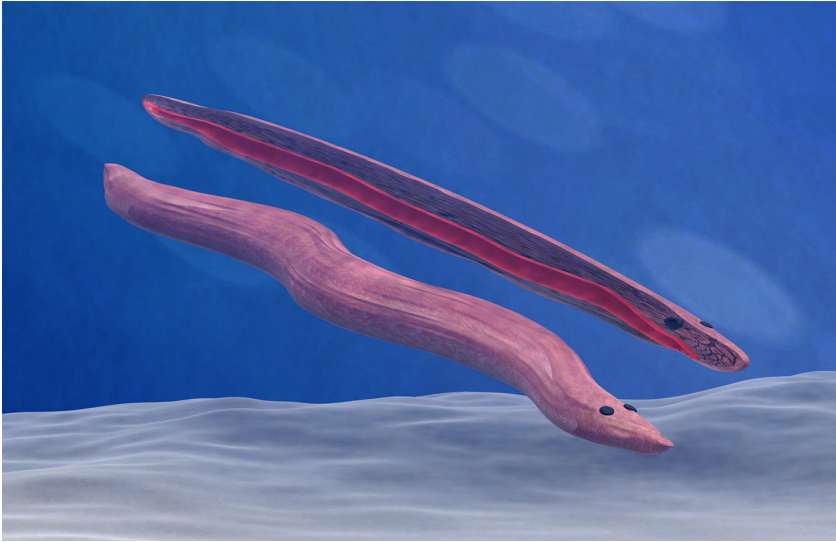


Figure 17.1: *Representation of an early form of worms, with a cross-section showing the digestive tract and the brain.*

successive cycles of divisions of a seed-cell. The emerging creature first resembles a hollow sphere, but soon an opening appears at one extremity, transforming the sphere into a vessel. Another aperture also soon develops, and the vessel now becomes a tube, as if its development recapitulated the steps of its evolution.¹ The rest of the creature then emerges out of repeated cycles of division, refining the details of this tube, carving its intricate network of nerves, weaving muscle fibers into bundles and tissues that will grant the animal its freedom to roam the salty waters of the ocean.

The spherical nature of the dividing cells first favored the emergence of larger, multi-cellular forms of life that also shared the shape of their building blocks. Only under the influence of selection pressures was this sphere broken, when new shapes and structures began to provide an edge for survival and reproduction. The perfect symmetry of the sphere was thus completely broken, as the body of the first animals, sponges, grew to immense pro-

¹Even though some stages of our development indeed resemble some of the steps of our evolution, many counterexamples exist. Many early scientists researching evolution, such as Ernst Haeckel, believed in the so-called “recapitulation theory,” arguing that development recapitulated the evolution of lifeforms, but it has since then been proven to be clearly false.

portions relative to the size of their building blocks. Having yet to learn to optimize and direct their growth, the cycles of divisions of their seed-cell, these early animals appeared as largely disorderly blobs, nonetheless developing series of tubular cavities mainly used for feeding. As their descendants were subjected to the most merciless selection, they were forced by nature to very precisely control the way in which their seed divided and the structure formed by this remarkable assembly. Inscribed in the library of information of a seed-cell is the plan detailing the unfolding of this structure, a plan that is the result of countless attempts that cost the lives of a multitude of animals. The manifold symmetry of the sphere was still ineluctably broken, but part of it was nonetheless preserved. The body of animals such as the jellyfish indeed adopts an elongated shape, thereby breaking the perfect symmetry of the sphere, but it still exhibits a symmetrical shape across a set of planes centered around one axis, a so-called “radial” (wheel-shaped) symmetry. The spherical seed becomes a cylindrical vessel, with a single opening, whose structure is regular, repeated across the different planes of its axis of symmetry (See Fig. 17.2).

The symmetrical nature of the developing creature is therefore very “natural.” It represents the most basic state of a developing living thing. This body can be shaped when it grows too large, by the forces of nature such as gravity, the pressure exerted by water, or the hardness of the earth, among others, as is the case with some sponges, thereby breaking this natural state of symmetry. Life may nonetheless also itself fracture such symmetry to gain an evolutionary advantage, as is the case with the jellyfish, but it does so very progressively, only once it has figured out a way to take advantage of this transformation. The cylindrical vessels such as the jellyfish therefore continue to exhibit a radial symmetry, not because such structure would present some inherent benefit, such as a greater simplicity to build it for example, but rather because such a symmetry would naturally appear when a seed-cell successively divides itself many times.

The advent of the first worm-like creatures in the sea represents a new milestone in the topological evolution of animals, one that is as much the result of the forces of nature, the earth, the sea, and the sky, as it is the product of life itself, through the process of selection. The impulse of independence, the detachment from the seafloor, has triggered in these free-swimming animals

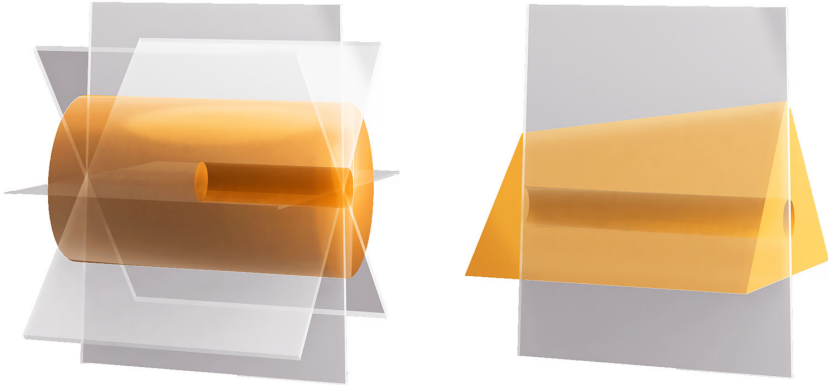


Figure 17.2: *Transition from a radial symmetry (on the left) to a bilateral one (on the right).*

the discovery of the world around them, and of its arrangement in particular. The swimming vessels, with a single opening serving for ingestion and excretion, are characterized by the cavity and the opening allowing them to feed. They have a kind of orientation, due to the localization of this opening, but not a true polarity, as they have a front mouth but no true backside. The first worms, on the other hand, were probably swimming tubes, but as their sensory perception increased, along with the complexity of their world, that is, their representation of their surroundings, they discovered the advantage of the shattering of the radial symmetry of their body.

The early worms soon discovered ways to perceive the light of the sun piercing through the skin of the ocean. This allowed them to find the surface more easily, something that may have made them capable to more easily locate light-workers that could satiate their hunger, as these would be found near the surface, where light is abundant, rather than in the shadowy depths. It, perhaps more probably, also allowed them to escape predators by staying in dark places, away from the surface. Far from being true eyes offering them a picture of the content of the ocean, these were at first mere light-sensitive spots, only indicating the presence or absence of light. This is nonetheless enough to provide an edge over other creatures, and as this light at this point would almost always come from the sky, the animals then naturally developed a vertical orientation, a differentiation between the upper and lower

parts of their body, with an upward side where light sensors are needed, and a bottom side where they are not. Another important factor may also have played a decisive role in the emergence of such a vertical orientation: the fact that a significant amount of food may be found on the sea-floor, where the cadavers of past living things are deposited by the currents, the collection of which would be easier with a bottom-facing mouth, as it is the case with many kinds of worms.

The heavenly forces showering the ocean with light, that is, the sun, the moon, and the stars, therefore shaped the upper part of the worm's body, while the earth, the sea-floor, formed its lower part. Earth and sky applied pressure on generations upon generations of these animals, which were guided by these forces of nature, with which they became increasingly familiar and even intimate, as their senses grew more attuned with the world into which they were thrown. This pressure led to a collapse of the radial symmetry, with the many planes of symmetry, distributed around an axis going from the front to the back of the creature, then reduced to a single plane, forming a so-called bilateral symmetry, from which this offshoot of the animal branch of the tree of life takes its name: *Bilateria*.

The bilateral animals are characterized by front and back sides that can be distinguished from one another, as are their upper and lower sides. Certain features of their body, such as a brain, eye-spots, or a mouth, are only present on a single one of these poles. They nonetheless preserved one plane of symmetry, which is also the one that has been (mostly) preserved by ourselves, as very distant descendants of these primitive bilateral worms. We, like them, are endowed with a body that could be cut in half along one axis and the two halves would represent an almost exact copy, although a mirrored one, of the other.² Most animals indeed have no need to distinguish their left from their right. The forces of nature exert no pressure upon them that would lead to a breaking of this last plane of symmetry,³ and they therefore kept this simple and beautiful arrangement of their body. Swimming in the vastness of

²In our body, there of course are a few exceptions, such as the heart.

³Some animals would nonetheless later break this symmetry, as the result of particular evolutionary pressures. One of the most remarkable examples of this would certainly be the *fiddler crab*, which has a very large claw on one side and a small one on the other.

the sea, there is indeed no crucial need for a distinction between right and left, and this particular symmetry facilitates a snake-like manner of swimming, which is particularly efficient. The sea is a vast horizontal expanse, covering most of the face of the planet, bounded by the sky above and the earth below. The animals' living space is therefore mainly horizontal, a seemingly boundless mass of water in which every drop is mostly indistinguishable from another. Roaming through such a largely translucent territory, both sides look exactly the same, and there is therefore no advantage in distinguishing them. They thus adopted the shape of a triangular prism, pierced through and through by its digestive tract, a shape that represents an optimal arrangement considering the environment into which they were thrown.

If a triangular prism can indeed represent the first bilateral animals, it would nonetheless be one whose front size would be larger than the one of its back. Indeed, endowed with a series of burgeoning senses, individuals were selected for the efficiency and economy reflected by their network of nerves, and therefore those who had more of them at the very front were favored by life. As the worms swim, tracing an undulating line in the waters, the senses at their front are indeed the most crucial ones, as this is where food can be found and ingested, and where threats can be the most quickly and successfully detected. The mouth, the eye-spots, and the tentacles are therefore all concentrated there, and as the complexity of this network grew, a brain emerged at the same location, able to process the information coming from the countless nerve cells as swiftly as possible, integrating these pieces of information to produce a response, guiding the movements of the body. This entire series of transformations and concentration led to the formation of the head, which represents the core, the "heart" of the animal, the part of its body that is the most vital.

The distant ancestors of the worms, single cells, also underwent such a movement of concentration of their most crucial parts. These cells were miniature bulwarks facing numerous threats and having few means of evasion or defense and they therefore secured their wealth in the geometrical center of their spherical body. Contrary to them, the worm's center is no more protected than its extremities, and the creature has a far greater need of these most precious parts where they can be used: at the vanguard of its flesh, scouting for new discoveries at the very front of the body.

The head and its central command, the brain, allow coordination of the movements of the entire body, like a hierarchized army that could overcome any disorderly mob of warriors. *Cephalization*, the emergence of a head distinct from the rest of the body, therefore implies faster responsiveness and more complex, more aptly chosen reactions, and it thus offers an advantage that was positively selected after many generations.

The centralization of the most crucial parts of the nerve network and the mouth also opens up new possibilities, which are soon discovered and exploited by the early worms. As other individuals and other branches of the animal kingdom also have developed their senses, some of the worms soon discover a property of the waters that they ignored until now: its transparent nature, which reveals their presence to other living things, just like it can help them locate prey or predators, no matter how rudimentary this sensibility to light is. Finding themselves naked and exposed for all eye-spots to see, some of them therefore decided to abrogate their until then very fruitful alliance with the sea, which began when their ancestors severed their dependence and anchorage with the earth, which began with the first sponges, to enjoy the freedom of the ocean. They will nonetheless not forget the benefits of the freedom gained by their forefathers and passed on to them through their germ-line. They do not bind themselves anew to the earth, attaching themselves to the rocks of the sea-floor, but rather decide to take advantage of a territory that allies earth and sea, mingling them to open up a space that offers the benefits of both: mud.

A layer of mud can be found between the hard, rocky earth at the bottom of the sea and the vast expanse of water above it. A subtle blend of water (sea), minerals (earth), and the remnants of formerly living things (life), this milieu offers an attractive compromise to the animals. Contrary to the earth, it can be penetrated by the soft body of the animals, although with some effort. Contrary to the sea, it is perfectly opaque, offering cover to the creatures wishing to escape the prying eyes of other beings. Some animals therefore occupy this peculiar space, intermittently at least. Its viscosity does not allow them to efficiently move inside it. They thus use it as a place where they will mostly lay still, waiting. It serves two major purposes: as the creature lets its head slightly protrude from the mud, it can lie in ambush, far less detectable

than when it is swimming in the open sea, until a living thing passes nearby, at which point it can pounce and devour it. The same property of the mud also allows the animals to hide themselves, covering their body while they rest or simply wait for a threat to vanish. As they continue to explore the ocean, these animals therefore grow increasingly intimate with a greater range of territories, playing with the earth and the sea, letting themselves be shaped by them while taking advantage of what they can offer. The upper realm, the sky, is nonetheless not without influence upon these beings.

The two elements previously mentioned, the emergence of light sensitivity and the discovery of the muddy space lying between earth and sea, are both also linked with the appearance of a phenomenon that will occupy a significant part of the lives of most of the descendants of the marine worms, including ourselves: sleep. Living creatures may already at this point have been able to perceive the effects of the daily veiling of the sun or the successions of the seasons linked with the dance of the planet around the fiery orb, but it would seem that the perception of the envoys of the sun, coupled with the ability to swim in the sea and to burrow into the mud, may have played a decisive role in the appearance of sleep.⁴ If a creature relies extensively on its capacity to perceive light in order to find food or avoid threats, it is indeed rapidly confronted to a problem: the source of its enlightenment indeed disappears for approximately half of the day, depending on the season and the latitude. This means that during the dark hours, when the shining sphere has retreated beyond the horizon, the creature will be considerably weakened, less able to feed itself and more vulnerable to the perils of the ocean. The gentle glow of the moon or the feeble gleam of the milky way may slightly alleviate this burden of shadows, providing a few moments of relative clarity near the surface of the murky waters, but day and night will nonetheless already correspond to two different periods in the life of the marine worms, and they will slowly develop specific behaviors tied with each one of them.

The day is therefore a time when the animal has the best

⁴Concerning the appearance of sleep in marine worms, the following reference provides more information: Maria Antonietta Tosches, et al. "Melatonin Signaling Controls Circadian Swimming Behavior in Marine Zooplankton". *Cell*, vol. 159, no. 1, Sept. 2014, pp. 46–57

chances of succeeding in finding food, a mate, or detecting the presence of danger. These hours when the sun shines upon the face of the ocean are the ones during which the energy of the creature will be most efficiently spent. In contrast with the day, the dark hours of the night offer fewer opportunities to satiate its hunger or satisfy its desire to mate. Instead of wasting its efforts blindly roaming the shadowy waters of the night in hope of randomly stumbling upon a source of nourishment, and potentially face invisible predators, it is more efficient to lay low during this time of unawareness. Retreating in a muddy lair is therefore the best strategy for survival. The worm therefore takes shelter in the opaque space between earth and sea, patiently waiting for the dawn and the deluge of light that will pierce through the surface of the ocean, cure its blindness and deliver it from the dangers and idleness of the night. During the long hours of waiting between dusk and dawn, the being minimizes its consumption of energy. It not only remains motionless but also reduces the activity of the inside of its body. Its senses are dimmed to a minimum, as they will only be necessary to detect a direct contact with a threat, and it therefore also loses perception of the time that passes. Time is therefore suspended during these dark hours, in the world of the animal at least. The worms may not be able to experience dreams, but this phenomenon, very familiar to us, nonetheless takes its roots in the adaptation of such primitive animals to the celestial course of the sun, the moon, and the stars.

Re-flection: The Directions Within Us

The celestial bodies shining throughout the skies, the sun by day, the moon and the stars by night, including the earth upon which the tree of life unhurriedly grows, all share a similar shape. The perfect simplicity of the sphere is the form of choice of nature, one not only found in the sky, but also in the infinitely small depths of life, the cells, or those of the earth, the atoms.

Observing a sphere and manipulating it, we may notice how it exhibits a manifold symmetry, as its appearance remains unchanged while we rotate it across the three axes of our space. A sphere has no up and down, no right or left, but rather only displays an absolute uniformity. It is the shape favored by things that are themselves subjected to uniformly distributed forces, as are the planets in the emptiness of the cosmos or the isolated cells floating in the ocean.

The bodies of the animals crawling on the earth, swimming the seas, or soaring in the sky are not so, as their peculiar shapes reflect the actions of the hands of the earth, life, and the sky kneading them. Once the senses of the creatures lifted the veil that until now covered the earth and the sky, they discovered the disparity of the environment in which they were thrown, its unevenness.

In the dark depths of the ocean, all directions bear the same significance or absence of it, but in the shallows where the day shines with all its might, light only comes from above. When standing upon the rocky surface of the earth, the air we breathe is found above it, while the impenetrable but stable ground toward which we are pulled is always below us.

If the front of our body differs from our back, it is because of our distant marine ancestors, as their body evolved to take into account the difference between the realm above and the one below. Swimming in the vastness of the seas, they observed the light shining over the surface, and they explored the muddy floor, needing different senses on the two sides of their bodies.

The linearity of their movements in the water also induced the breaking of another symmetry, as their front, with their mouths and eyes, began to be differentiated from their back. We inherited this evolution, now having our head above our shoulders and our

backside below, and can imagine ourselves swimming in the water and the advantages it would still provide us.

The topology of our body has not been fundamentally changed since the time of our marine fathers, as we are tubes of flesh, ingesting food from our mouth and excreting its remains from our back. Each day of our lives, the pace of our existence is set by this activity tied to our survival, this filling of the tube with the building blocks of life, feeding the furnace burning inside us.

We can thus observe our body and see how the earth and the sky have shaped it. Most symmetries of our seed-cell have been broken by them, but one has been preserved, as even though our upper and lower body, front and back sides are all significantly different, our right and left sides are almost identical, mirrored images of each other.

If this unique symmetry has been preserved, it is because of the nature of our habitat. Swimming in the sea or walking over the earth, our world is a thin layer between earth and sky, one that is pressured from above and below, leaving us only free to explore its horizontality. The space we explore and appropriate every day is the middle realm found on our left and right, where there is no immutable and clear point of reference, no omnipresent force constraining us. Moving through water or air, there is no fundamental difference between our left and right, and thus our body simply reflects this state of fact, mirroring what does not need to be distinguished.

Closing our eyelids and lying down, relaxing every muscle of our body, dimming our senses, we may now pay attention to what occurs to us when our world is deprived of its light, when the sun passes beyond the horizon, and we are unable to distinguish sky from earth. Living on the dry land and pulled toward the earth by the weight of its iron core, we even in the dark can feel the up and down sides of our world, but our ancestors did not. Their reference points taken away, our marine forefathers were disoriented during the night, and thus did life discover the benefit of sleep, avoiding dangers by lying low in a secluded place.

One-third of our existence is spent sleeping, relinquishing our consciousness and reason, experiencing an illusory world where joys and fears are experienced as if they were real. We owe these

periods of rest and wonder to the nature of the upper realm, to the veiling of the sun, as it deprived our forefathers of their heavenly beacon and invited them to imagine rather than to see.

Chapter 18

From Many to One: Social Animals

The worms are now endowed with a variety of senses, each one of them providing an almost continuous flow of information that finds its way into a particular dimension of their world. Their eye spots bring them a contrast between sea and sky, the dark night and the luminous day. Their sense of touch allows them to map their surroundings and identify different substances with which they enter into contact, according to their hardness or roughness for example. Finally, their sense of smell allows them to detect the presence of particular compounds in the water in which they swim, and also infer the presence of other living things in their vicinity, following these traces like a bloodhound or on the contrary fleeing from them if they are signs revealing the closeness of a threat. This palette of senses can not only be used to explore the realm of death, the earth, the sea, and the sky, to bring them into the creature's world, or simply to escape death, brought on by predators. It can indeed also be used to interact and to create bonds with other living things, those with whom the animals share a large part of their own nature in particular.

As seen earlier, the single-celled ancestors of the marine worms already discovered ways to interact with their peers through the perception of particular substances used as signals. Their descendants therefore use similar strategies, but in their case, these are considerably enhanced, because of the fact that their interactions



Figure 18.1: *Encounters between animals.*

are largely ruled by their brain and the rest of their nerve networks, offering a considerably broadened range of reactions and adaptability. Contrary to their relatively passive single-celled ancestors, the worms are very active, not waiting for the earth, the sea, or the sky to bring them what they need, but rather seeking it and taking it. The war they wage for their survival and their posterity is not a mere passive resistance, a series of stratagems to evade or counter the assaults of nature and other forms of life. It is an unceasing battle during which they are almost continuously on the move, attacking or defending, seeking or evading. Those fighting an endless war nonetheless need allies, and those acting with loyalty and selflessness toward the group that they form will have the best chance to prevail over their common adversary. The emergence of positive interactions and mutually beneficial bonds is therefore not only possible but almost ineluctable.

The battle for life waged by the animals occurs on a progressively grander scale, but the principles ruling this game are very similar to those that led to the emergence of life and guided the growth of the tree that it forms, from its very first seed. The play of attraction and repulsion, affinity and strife, love and war, can indeed be observed as a central force directing the interactions be-

tween individual animals. It is through the complementarity and also the opposition between these poles that these creatures can continue to discover new possibilities offered by life and become more successful in their endeavors. The need to find an appropriate mate to produce a viable and fit offspring or to defend themselves as a group draws those belonging to the same kind together, but the limits of a feeding or hunting ground may also tear them apart, forcing them to fight against one another for resources and part ways. An equilibrium between a necessary proximity and distance must at all times be sought, and this is where the remarkable flexibility offered by the brain comes into play.

A great number of generations of animals are therefore used and sacrificed by life in order to discover what kind of configurations, what kind of wiring of the nerve network would lead to more efficient patterns of interactions between members of the same kind, patterns that would offer those following them an edge over other individuals and other groups, helping them to survive and give birth to fitter descendants. One of the most crucial innate abilities that came as a result of such selection certainly is kin recognition, the capacity to identify one's closest relatives. This, in turn, allows the broadening of the play of affinity and strife, love and war, through which selection and evolution occur. This play will now not only lead to a selection on the level of individuals but also on the level of a larger circle, including their relatives, those who share a similarity of their essence, of the library of information at the heart of each one of their living building blocks, their cells. As every single form of life nonetheless shares a common ancestor, a common essence, each animal will therefore be forced to continuously reevaluate the size of this circle, which will mark the boundary between kin and stranger, and often also the one between affinity and strife, love and war, friend and enemy.

The flow coming from the senses that is poured into the creature's world and used to edify it, which was already cleaved according to different criteria that often are binary oppositions such as edible or inedible, safe or dangerous, potential mate or not, is now also used to distinguish kin from stranger. Even though the brain of the marine worms may appear very rudimentary compared to ours, it is nonetheless already a formidable piece of machinery, able to process an incredible amount of sensory information to produce an adequate reaction to a very large range of situations. The eval-

uation of the degree of kinship performed by individuals on others is therefore already subtle, complex, and multi-layered. Different circumstances imply a different radius of the circle marking the frontier between kin and stranger, friend or foe, opportunity and threat. A general tendency will nonetheless emerge, one that can also be observed among men: the closer the kinship relationship is, the tighter is the bond between individuals. Parents and children will unite their strengths to oppose cousins. An animal will nonetheless join his cousins to protect their common interests when faced with a group of more distant relatives. The play of affinity and strife therefore takes place on several layers of groupings, as animals have developed the remarkable ability to gauge in real-time who should be an ally or an opponent, where is the line drawn in their world between who is supposed to be offered love and who should be subjected to the wrath of war.

The efficiency and wisdom with which the radius of the circle delimiting affinity from strife is chosen then becomes an important factor for the prevailing of a particular group, or a particular species, over another. Those who show too much altruism, having a circle of affinity too large, trusting others excessively, are taken advantage of by groups that are more tightly knitted, having stronger and closer bonds and therefore an edge over those that do not. On the contrary, those who are incapable of any altruism toward their kin, having a circle of affinity that is too narrow, fall prey to those who have properly balanced the need for a large group with the need for tight bonds uniting its members. There is, of course, no rule and no perfect compromise. Every equilibrium is transient, and every location in space and in time unique, calling for a tailored response.

According to the nature of their environments, animals therefore adapt their level of sociability. When resources are plentiful, the occupied territory sparsely populated, and predators are few in number and ferocity, they may be more successful living alone, only socializing for mating purposes. On the other hand, when food is rare and competition is fierce, alliances with one's kin may provide a decisive advantage. This is when the circle delimiting affinity from strife, kin from stranger, largely overlaps with another: the one marking, on the earth itself, the boundaries of the territories occupied and defended by particular groups. The sea becomes divided into parcels, each owned by individuals and

groups of them, in which only those belonging to the inner circle are allowed, proving their belonging by unique signals, received by the senses of the members and identified by their brain, which can take various forms, such as the shape of the body or the emission of particular odors.

When the members of a group are recognized by all its members, hierarchies can then emerge between them, with some individuals exerting a stronger influence than others. Herds can be formed, for migration or territorial defense, to conquer or to protect, to nurture or to kill. Invisible on the earth and in the sea, such hierarchy is displayed inside the world of each member, which shares many common elements with the one of their kin. There is nonetheless another fundamental property of the nerve network that emerges as the first marine worms evolve and open up new opportunities for life: the capacity to learn.

A large part of the architecture of the nerve network of animals is innate, built during their development, according to the plan contained in the library of information of their seed-cell. This architecture is far from random. It is the fruit of millions of years of trials and errors, with the individuals exhibiting the configurations the most suited to their environment reproducing in greater numbers and spreading their discovery among their kind. Knowledge is therefore embedded in the very topology of the network, a knowledge that is ultimately just another representation of the one contained in the library, as the long chain of bases is used by life to produce a complex and precisely designed assembly of nerve cells. These cells are nonetheless endowed with a peculiar ability, which will have tremendous repercussions on the destiny of the animal kingdom: they can change their own shape, and transform the connections binding them to their peers, thereby remodeling the nerve network driving the behavior of the creature. The processes through which such remodeling occurs have yet to be unveiled by mankind, but we are at all times the witnesses of their result. This capacity to rewire the nerves, constantly from infancy to death, has also been the subject of a severe selection, and as a result, animals have developed an ability to link such rewiring with the flow of information coming from their senses as well as from the flow running inside the network itself. The creature learns and adapts its network of nerves by taking into account what its senses tell it of the earth, the sea, the sky and the life that flourishes between

them, but it may, at least theoretically, be able to reflect, not in the sense of a conscious introspection but rather in the sense of being able to not only exploit the flow coming from the outside of the living being, its senses, but also its representations, its memories, and the entirety of its world that is supported by the network.

To learn is to be able to memorize and to react differently to a situation already encountered before. Such learning may come as a result of a teaching by the earth, the sea, the sky, or other living things, just as it may come as a result of the processing of memories, reflection, or even illusory perception, such as hallucinations or imagination. Learning therefore considerably enhances the adaptability of an animal. Before, in order to learn, life had to sacrifice countless individuals to discover new knowledge, through the interplay of mutation and selection, the play of love and war. Only minute changes were possible between generations, and significant changes demanded a considerable number of years. Because of this new ability to learn, the brain may undergo significant changes during the very lifetime of the creature. New discoveries can be made at every instant, by every single member of a population. The very foundation of the creature's world, the earthly, physical network that supports its non-earthly, metaphysical representations, is like a patch of quicksand, but one that would be supported and bounded, offering both adaptability and support. More importantly, learning allows another extensive transformation of the animals' world: the possibility to share its content with other beings.

Those who have learned something valuable, through their life-experience, the flow of the senses or the one of reflection, can then teach. They can share with others the harvest that they have reaped. What has been discovered by the old can be passed on to the young, creating a new way for knowledge to be accumulated and preserved. A new dimension of the world is therefore opened up. A new space is supported by the earth, the material network of cells, one that transcends it by using it to create immaterial representations. The knowledge discovered, gathered, and preserved by life is from now on not only passed on through the reproduction of the library of information of the cells but also through teaching and learning, through direct interactions between beings, long before the animals doing it have any notion of the nature of their actions. The amount and range of what can be learned are nonetheless di-

rectly correlated with the sensitivity and spectrum of the senses of the learner. One needs a finely tuned apparatus in order decipher the knowledge of the teacher, which is at this stage not communicated through an articulated language but rather through signs, taking different forms: it may be a scent, a movement, a sound... each one of which may be assigned a broad range of meanings. The sign may indicate the presence of danger, the direction where nourishment may be found, or the fact that one would be ready to mate. In many places, the animals that possessed the best sensory apparatus had an edge over others, and therefore their lineage developed an increased capacity to unveil the meaning of the signs created by their kind. There are nonetheless also places where these senses did not provide a significant edge, explaining why some rudimentary creatures were not supplanted by natural selection.

Learning animals, the interpreters of signs, nonetheless need teachers, beings able to communicate meaning and create these signs. The nerve network must therefore also conjointly evolve, being once again selected, mainly on the level of the innate architecture of the network, which includes the capacity to teach and learn, so that the being would be able to emit as well as to receive signals. As was the case with the signaling that emerged between single-cells, one does not need any consciousness in order for this to occur. The signs are not the product of a willful act of creation, but rather naturally emerge, beginning as random behaviors, which are carefully selected by life. When a randomly created sign is by chance correctly associated with a particular meaning and a particular reaction from those decoding it, both the emitter and the receiver may have a greater chance for survival and reproduction, starting a virtuous cycle by which such useful signs are preserved and accumulated, as long as the edge that they offer perdures, while others fade into oblivion.

The capacity of the animals to communicate is then correlated with their ability to socialize, with their own kind in particular. Indeed, a lone creature roaming the seas will mostly be surrounded by death, by the earth, the sea, and ultimately by the all-encompassing sky, whose pace is slow compared to the one of life and which offer few stimuli to a creature eager to learn and build up its world. In contrast with this, interactions with other forms of life, those that do not pose any threat in particular, may

offer the creature a continuous stream of stimuli, triggering its senses and helping it to learn to react swiftly and efficiently to the movements and signs offered by another. The more the animal is stimulated, the more it will learn, developing its intelligence, here understood as its capacity to appropriately react to different situations.

One of the most significant changes brought on by the emergence of learning and signaling among animals is the fact that a collective knowledge, spread around an entire group of living things, can be accumulated and communicated across space and time, without the need to embed it in the library of information of these creatures. A process that is very similar to the way by which the library of information emerged, as the result of the play between mutation and selection, love and war, now occurs within the animals' world itself, in the space of all their representations. Random signals are tried and when some of them are found useful and help those using them to gain an edge for survival and reproduction, they become "meaningful" and are propagated among their descendants, taught from generation to generation rather than transmitted as innate properties. What emerges from this accumulation of meaningful signs is a *culture*, a treasure-house of knowledge, traditions and conventions, that is shared across the members of a group and across generations, continuously evolving according to the needs of the life of their members, like a plant nurtured by successive generations of gardeners.

Culture therefore represents a new layer of information, one that is spread across a population rather than being the property of an individual, contrary to the library of information of the cells. This distributed nature of a culture is nonetheless not a mere safeguard for its preservation or a way to bypass the impossibility to easily modify the library of the cells. The signs forming the culture are meaningful only because they are shared. It is through their distributed nature that their usefulness is manifested. A teacher cannot teach if none of the students understand his language. This nonetheless does not mean that signaling would not occur outside of this shared knowledge-space. The flesh of the animals still continues to evolve, albeit at a slower pace than their culture, and therefore signaling may also emerge, as innate characteristics of their body rather than learned behavior. Certain patterns or colors found on the skin, for example, may be used

to signal a dangerous nature, discouraging predators from eating them. The play of change and selection therefore continues, played both on an earthly level, through the slow evolution of the library of information and the flesh of the animals built using its knowledge, and on a worldly one, through the development of a culture of learned signs, occurring on a considerably faster pace.

The marine worms may be one of the first kinds of animals able to learn through social interactions, and they laid the foundation of the intelligence of all their distant descendants, including ourselves. The reading of these lines would not have been possible without their work, as pioneers of communication.

Re-flection: The World Between Us

Self-replicating chains sought refuge within spherical walls during the infancy of life, and thus prevented the extinction of the first sparks of life, replacing those that remained shelterless. Life then learned that by binding the fate of cells together, these could vanquish competing lifeforms, and thus compound beings sprouted out of the tree of life, soon reigning over its entirety.

Life overcomes the constraints limiting the propagation and growth of its fire by bypassing them, as it forms assemblies using what has reached its limits as the building blocks of new structures. Their growth reined in by the rigid nature of the bits of earthly matter from which they are made, cells thus were joined together to form plants, fungi, and animals, breaking their chains.

Growing to form gigantic structures composed of an astronomical number of cells interacting with one another, animals were soon also confronted with boundaries constraining their incredible expansion and refinement. Once again, life would nonetheless find a way to continue its patient conquest of the earth, discovering that entire animals could form communities acting as a whole, stronger than any individual.

As our cells communicate with one another to form our body, out of which our being and world emerge, we by our interactions with other humans are part of a whole, something that transcends our own being. We are the pillars supporting a new stage of life, in the same manner as our cells support our existence. Forming bonds with others that can be extremely complex, strong, and continuously changing, our kind allows life to reach new summits of adaptability, explaining our rapid conquest of the earth.

The key to our prowess certainly lies in our capacity to remember and learn from our experiences. We do not simply rely on our instincts, inscribed in the library of information within each one of our cells, but rather continuously evaluate the world around us, deciding what should be loved and what should be fought. We may now think about how our behavior has been influenced by a particular experience in our past, and consider how we have influenced those around us through our interactions with them.

Our first relationships, those with our parents and siblings,

often have the deepest impact on our lives. They normally should teach us the virtue of trust, the strength that comes with sharing and loving, in contrast with reserve and caution that should be exhibited toward the unknown, for survival. What guides our delimitations between who we love and who we hate, who attracts us or repulse us?

The very portion of space that we occupy at this instant is also part of the stage of the great play, as we know to whom this space “belongs,” who is welcome in it and who is not, as it is inscribed in our world. Our community determines the rights of each individual, through an unceasing interplay of interactions, with the entirety of the earth and the sea cut into pieces that are the property of persons and groups.

Our world views the earth, life, and the skies through a multifaceted prism, superimposing colors on them. The myriad of things around us are classified by this world into countless categories, and this world, standing upon the earth, is fundamentally dual, the product of both instinct and learning. The foundation of our world is given to us at birth, written in the library of information of our cells, but countless structures have been built upon it by our ancestors, and this part is discovered after birth.

Smelling an extremely foul odor, the disgust we feel in our body and our mind is not learned, and neither is the pleasure enrapturing our heart when we unite our flesh with another human being. The attraction or repulsion that we feel concerning a particular person’s personality is different, as it is the product of countless experiences scattered across the path of our life rather than instinct.

As we recollect our interactions with other men and women around us during the last few days, we may reflect on the role we play in our community, in humanity, and in life as a whole. Through our deeds and words, do we edify our common world for the benefit of life and favor its appropriation? As the cells of our body play their parts in life, do we play ours, and what is our common goal?

Chapter 19

Flowing Energy: Blood and Circulation

As told in a previous chapter,¹ the light-workers found a way to harness the strength of the envoys of the sun, and they filled their celestial storehouse with the fruit of their labor, the chemical beasts known as oxygen. It would seem that this wealth offered to life, by the humblest of its members, was a critical factor leading to the great diversification of life that occurred soon after cells discovered the fact that these chemical beasts could themselves be used to help them release the energy found in nutrients, tearing apart the bonds forming these substances and allowing the use of their force to set their muscles in motion, to stir up the flow carried by their nerves, and all the other tasks performed by the body of the creature. This prodigious repository of energy that fills up the sky and enshrouds the whole of the earth and the seas is shared by all the descendants of these pioneers, who first made use of this celestial treasure, but as it is the case with men, an excessive abundance and wealth may ensnare and enslave the one who possesses it. One may find itself possessed by one's own possessions, because of the dependency they induce.

Several of the largest branches of the tree of life therefore began to be constrained by their dependency upon the storehouse of energy of the light-workers. The lone cells and the first com-

¹See Ch. 1.6.

plex creatures indeed relied on the natural diffusion of the oxygen carried and transported in relatively small but sufficient quantity by seawater. The chemical beasts are indeed small enough to pass through most of the outer barriers of the cells and then be harnessed by its diligent working molecules, but as animals grew larger, the limits of such a natural movement of diffusion of the beasts throughout the body were soon reached, reining in the growth of the creatures. The innermost parts of their body would be starved of energy and thus left incapable of performing their duties toward the whole if they were to grow any larger, but as the arms race between the different forms of life is at that point as intense and fierce as ever, due to the increase in number and variety of complex creatures, a tremendous pressure is still exerted on them, pushing them to increase their size so as not to become a prey and also be more ferocious predators. Once more, as the result of an incalculable number of trials and failures, life nonetheless found a way out of this evolutionary conundrum.

As the animals such as the marine worms develop from a seed-cell, which divides itself and produces an exponentially growing descendance that will form their body, three distinct layers of tissue soon emerge, each one of which has a precise series of functions. The innermost layer² mainly represents the digestive tube, which allows the digestion of food. The outer layer,³ on the other hand, forms the skin and the neural tissue that cover the body, including the brain. Between these two, a middle layer⁴ serves as the basis from which the muscles emerge, caught between the skin and the tubular space used to digest food and excrete waste. It is in this interstice that a solution was found to the problem of finding a more efficient way to deliver oxygen throughout the body, no matter what size it would be. Passive diffusion is largely abandoned and superseded by an active process. The flow of energy-carrying water cannot reach the innermost tissue and therefore the animal replaces it with one of its own making, tailored to fit its needs. A network of tubes, of progressively increasing complexity, is formed from the middle layer, one that envelops the parts of the body that have the least direct contact with the waters, the digestive tract (See Fig. 19.1). Contrary to the network of nerves, this one

²The *endoderm*, the inside layer.

³The *ectoderm*, the outer layer.

⁴The *mesoderm*, the middle layer.

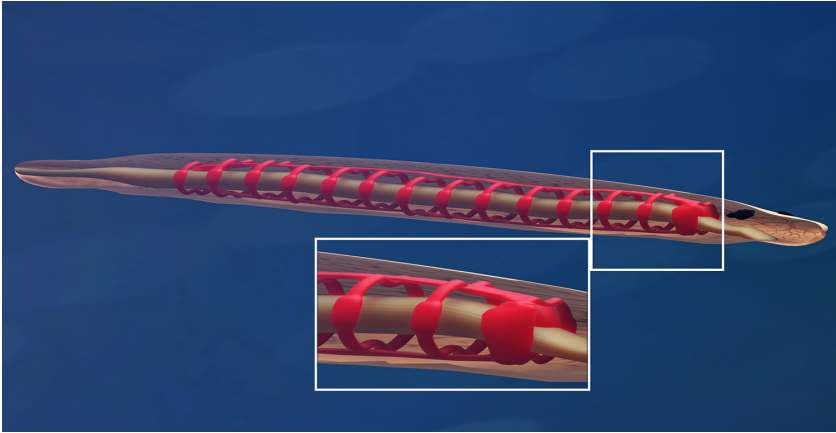


Figure 19.1: *The vascular system of a marine worm.*

forms a closed circuit, an intricate loop in which a liquid can flow, both preventing it from being spilled inside the body and allowing certain interactions to occur with what is in contact with these tubes.

The liquid flowing inside this circuit nonetheless needs to be imparted with a momentum. An impulse has to be given to it in order for it to run through this loop, and this is where the original purpose of the middle layer comes into play. The walls of some of the parts of the circuit are thicker than others and they are lined with muscles that allow the animal to squeeze the tubes like a water-balloon, setting the liquid in motion because of the pressure exerted on the walls of the tubes. At first, when such a network emerged, different parts may have been able to be contracted in such manner, with or without coordination, something that may have produced a somewhat erratic flow. An improvement nonetheless soon emerged, by which a precise location on the loop grew significantly larger and was lined with more powerful muscles, becoming the unique driving force of the flow running under the skin: a heart.

What flows within this three-dimensional circuit is of course not water, but rather the liquid that would later become a defining feature of life: blood. This fluid is nonetheless hardly comparable to the one forming the ocean, as it is not a mere flow of molecules used by the animals to carry the minuscule molecular beasts pow-

ering their body, part of the earth and the realm of death, but rather a river of living cells, fully part of the creature in which it runs. Blood is composed of a colossal number of cells, which emerged and were selected for their capacity to be the host to a relatively large number of oxygen molecules (O_2) and to deliver them throughout the body. Each blood cell contains millions of copies of a special protein (*Hemoglobin*), and in turn, each one of these contains several copies of a particular substance, in which a single atom of iron is found at its center, an atom that acts as a binding site for oxygen molecules, which can then be carried and delivered (See Fig. 19.2)

Blood is a living flow of cells, whose emergence marks a turn in the nature of the members of this branch of the animal kingdom. Until then, their body was a tube through which the remnants of past forms of life flowed, being slowly broken down so that the compounds they are made of could benefit their host, but a tube whose building blocks, cells, were largely static. These cells were part of a gigantic piece of machinery, continuously in motion, but these moving parts were the electrical signals sent by nerve cells, nutrients, or free oxygen powering molecular machines, rather than entire cells. Now, on the other hand, the blood cells are set in motion. They travel remarkably fast throughout the circuit assigned to them, serving as a giant transport medium for the proteins and compounds that perform the more minute tasks of the machinery of the body, with these compounds diffused into the body as they leave the bloodstream while the blood cells remain prisoners of the circuit. This marks a turning point where life, unable to grow because of the need for even the smallest part of a body to remain in the closest vicinity to the life-giving and life-sustaining flow of the sea, takes upon itself the task of imitating and replacing this fundamental force of nature. The sea cannot reach the depths of its flesh? Life thus discovers that it can create a flow of its own, a new sea enclosed within its skin, which would not only replace it as a means of delivering energy to the cells but even surpass it, allowing unnatural amounts to be accumulated and distributed, broadening the possibilities of evolution of the animal. Oxygen diffused through the skin is thus collected by blood cells flowing near it, without any organ specialized for this task, as would later be the case.

The blood circuit may first have emerged as a solution to the

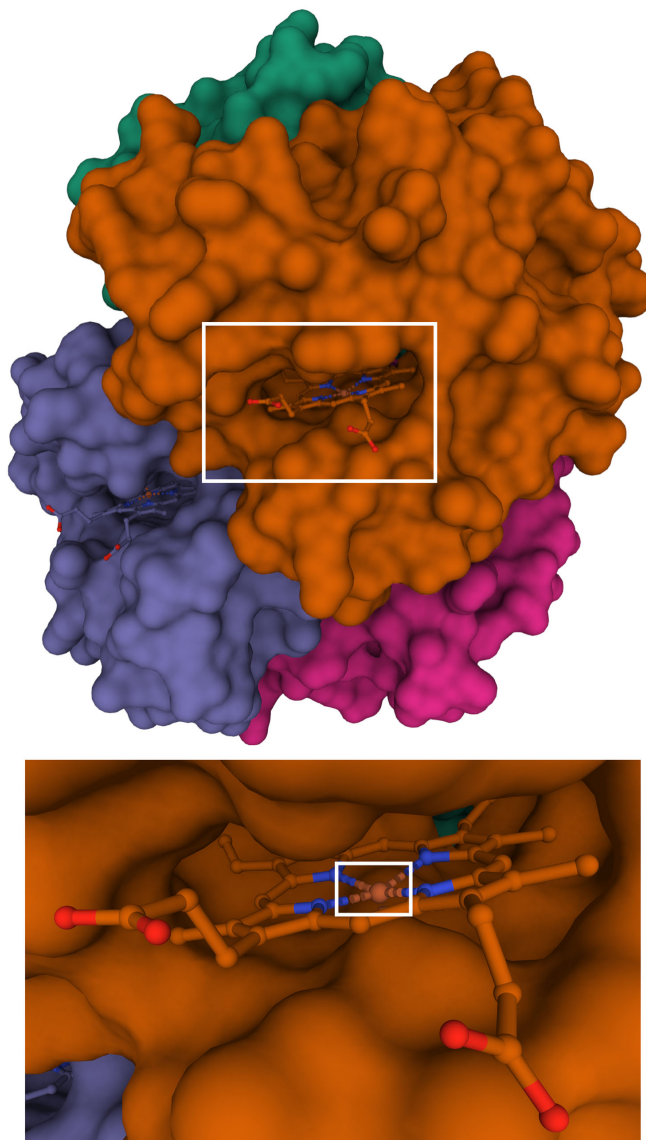


Figure 19.2: *A binding site of oxygen in hemoglobin.*

conundrum between growth and oxygen delivery, but a broader range of uses was nonetheless soon discovered for it. Like the sea itself, the bloodstream could carry almost any compounds needed in different parts of the body, with remarkable rapidity and efficiency. Defense mechanisms against invisible threats to the creature, such as infections by foreign single cells anchored on the skin or viruses having found their way inside the body, probably very swiftly took advantage of this delivery network, further enhancing the resilience of the animals.

As a result of the appearance of this wondrously developed circuitry, the constraint posed by the limited capacity of oxygen to naturally be diffused throughout the body is then loosened. The arms race is thus reignited, fiercer than ever, as creatures are selected for their size, which allows them to be well-positioned to eat others rather than be eaten. The great body of life thus grows in volume as well as in the number of individuals, occupying an increasingly greater part of the ocean, like an unborn bird growing inside its eggshell, feeding upon the yolk and patiently transforming it into flesh and blood. The wealth of the light-workers is put to good use, contributing to the edification of life, and its evolution, flowing into the veins of creatures roaming the depths, striving for their survival and the transmission of their precious library containing the discoveries of their long line of ancestors, up to the very first spark of life.

The life-giving properties of the bloodstream nonetheless also bring on a new danger to the lifeforms now relying on it for their existence. They are now not only flesh, soft elastic tissue that is made of cells tightly bound together, forming a compact whole that can only be torn apart with great efforts. They are also blood, a fluid composed of a multitude of free-running cells, not bound to any other, simply caught in the flux formed by their peers. Now a vital part of the body, they are only linked to it because of their nature as prisoners of the circuitry designed to shelter them. If this circuit is not closed upon itself, perfectly impermeable, the bloodstream would leak and run anywhere it could, carried by the impulse imparted to it by the heart, by the weight of the core of the earth, or simply mingling itself with the aqueous expanse of the ocean. If the animal is hurt in its flesh, by another creature or by the rage of the earth, the sea, or the sky, its fluid of life would therefore be spilled, rushing out to abandon the body, and if its

flux is amply reduced, the fire of life burning within the animal would soon be quenched, and it would soon once again become part of the realm of death. The power of blood therefore comes at a price, a new vulnerability that demands increased care for the integrity of the flesh. This would, in turn, lead to new evolutionary pressures, one for the maintaining of such integrity and another for the remediation of the threat posed by the spillage of blood, such as coagulation mechanisms.

Life owes to the earth the most central part of the circulatory apparatus. The atoms of iron that serve as a lasso holding the molecular beasts as they are carried where their force is needed are indeed originally part of another stream, the rivers of molten metal that run at the heart of the planet, with their weight keeping the ocean and the life flourishing inside it close to the earth. Even though they only represent an extremely small part of the bloodstream, they nonetheless give it its bright hue, the crimson red that catches the eye when blood is spilled out of the body, inspiring fear if it is one's own or blood lust if it is the one of a prey. Blood and rust share the same color and part of their nature, this gift taken from the flux poured out of the core of the earth, as if the earth allied itself with this branch of the tree of life, so that it could increase the size of its buds, fill up a larger part of the sea, and consume the wealth of the light-workers that is stored in the sky.

The bestowing of the gift of blood is nonetheless not a one-time event. The maze of minute streams covering the most inaccessible parts of the body is refined with the passing of each generation, with the most efficient and extensive configuration being favored by life, if it helps the animal to survive and out-compete its peers for mating. Like a tree, branching itself in a succession of increasingly fine branches and shoots, arrayed in a seemingly random manner but that nonetheless manages to offer a maximum surface coverage to the leaves that will receive the envoys of the sun while minimizing the expense in terms of resource and energy, such as wood, the mesh of blood vessels penetrating the deepest regions of the body is also branched into increasingly fine tubes, covering the entirety of the flesh, from the surface of the skin unto the core of the body (See Fig. 19.3). The former does so to reach the gift of the sun, while the latter does so to take hold of the wealth of the light-workers, which is itself derived from the same source, the

fiery orb that passes daily over earth and sea. The earthly iron is thus combined with the heavenly oxygen in the blood. Life, as the middle realm caught between earth and sky, thereby once again unites them both to build itself up, growing and maturing in the depths of the sea, the liquid that is neither earth nor sky, but rather the incubator and yolk of life.

The growth of the animals having discovered the power of blood continues for a while but soon, they are faced with a new stumbling block on the path of their evolution and their strife for supremacy over other branches of life. A larger size indeed implies a greater consumption of oxygen, and in the same manner in which the size of a single cell is limited by the ability of the surface of its outer layer to absorb what it needs from the water in which it is plunged, the minute concentration of oxygen that can be diffused through the skin before it is picked up by blood cells soon becomes insufficient to sustain further growth of the creature. Most of the wealth of the light-workers is indeed not found dissolved in the sea, but rather floats in the sky, where it is found in far higher concentrations. The marine animals cannot directly exploit the bulk of this wealth, but as they are continuously under pressure to evolve and grow further to prevail over their peers and competitors, life continues to explore the realm of its own possibilities to find a solution allowing it to overcome this limit.

The animals are nonetheless not completely masters of their destiny. Life as a whole is still permanently under the heavy influence of the earth and the sky, which shape it like a potter shapes a piece of clay. Both of them are continuously changing, themselves caught in the flow of time, and these changes have repercussions upon their offspring. The establishment of the causality between particular events having affected the earth and the sky and particular steps in the evolution of life is often uncertain and problematic, such as the influence of oxygen levels, and therefore details will not be here discussed, but one thing is certain: the state of the earth, the sky, and life can directly and profoundly affect life. If oxygen is found lacking in a part of the sea, the forms of life relying on it will die out or need to evolve and put an end to this dependency. On the contrary, a great abundance of it would certainly benefit the creatures able to exploit the energy it provides. Life is paced by the rhythm of the sky, the cyclic revolution of the earth around the sun and the course of the other celestial bodies. The passing



Figure 19.3: *A tree reaching for light and blood vessels reaching for oxygen.*

of the eons leads to great variations of the earth and the sky, with the planet at times becoming a frozen wasteland covered in snow, while at other an arid desert in which life desperately tries to survive. Between these two extremes, times of plenty also occur, with life flourishing like flowers and grasses in the first weeks of the spring. The size of the creatures filling the seas therefore evolves in reaction to these events, with smaller sizes favored during some periods and larger ones during others.

The pace of the individual animal nonetheless now also mirrors the larger pace of life and its relationship with the earth and the sky. The flow of the rivers of blood running within them is continuously attuned by the heart, often in response to the information collected by the sense about its environment, the sea. The presence of danger, be it from the sea or the earth itself or from other forms of life, will demand a more intense flow, allowing a greater consumption of energy, whereas calm and empty surroundings will induce a gentler and un wasteful flux. The beating of the heart then becomes a key symbol of life itself, a sign that indicates that a being still belongs to life, a testimony to this belonging, while its absence proclaims the return of the creature to the realm of death.

Re-flection: The Blood Within Us

The invisible fruits of the labor of the light-workers fill up the azure sky, the celestial storehouse, while most of the tree of life draws the energy sustaining its existence from this heavenly well. The molecular beasts in the air are used by our cells to release the energy stored into nutrients, and thus the content of the celestial vault powers a work of alchemy, turning food into life.

Those among the living endowed with a small enough stature may simply let these beasts seep through them, penetrating the pores of their skin and finding their way throughout their tiny bodies, where they are needed. Growing in stature, some of our marine ancestors soon saw their entrails become inaccessible to this flow, and thus life discovered the benefit of replacing the external flow of water with another, one flowing inside a being.

Life took upon itself the charge of replacing the sea, itself ferrying the beasts throughout the body. An astonishingly intricate web of blood vessels began to pervade the flesh of our forefathers, with one part of it lined with increasingly strong muscles, powering the flow inside it: the heart. Symbol of our life itself, the rhythmic circulation in this circuit sets the pace of our existence, and like when the sound of the beating of the drums of war gives place to silence and stillness, the failing of our heart marks the defeat of life in its relentless battle against the earth and death.

Taking our hands to our chest, we may feel the beating of our heart, the burning of the fire of our life. Largely out of our control, we may pay attention to how it varies with our emotions, with our efforts, taking heed of how these efforts are made possible by the flow of oxygen running through our veins. This continuous race of blood cells running in the loop covering the entirety of our body, it began as we were in the womb and will continue without interruption, until the day of our death.

The living flow, the crimson rivers to which we owe our existence, are a gift of the earth as much as the sky. The realm above provides the beasts in the air, but the one below offers the tools for their harnessing, as each molecule of oxygen carried by our blood is attached to an atom of iron, blood of the earth. The liquid of life wears a rust-colored coat due to the presence of this metal flowing in the core of the planet, and it makes its way into

our flesh through our food, in the same manner as molten magma is poured into sea and onto land.

Observing our blood vessels by applying a strong light on our fingers or remembering it being spilled, we may contemplate the twofold nature of our blood, which allies earth and sky, iron and oxygen. It imitates the currents of the ocean, the rage of the waters, to bring the fruit of the heavens to our cells, and at each instant, myriads of encounters and separations between these sons of earth and sky occur, representing a wondrous example of the beauty of the astonishing piece of machinery we call our body.

Picturing the spilling of blood, we may heed the feebleness that also comes from the crimson river, as we are pouches of liquid, wine-skins of thin leather, always under threat of a rupture. Our flesh needs to be tightly sealed to retain the precious scarlet fluid, composed of innumerable cells, as each one of them has no anchor-point to our body and would run into the earth if given the chance. The loss of this stream of lilliputian rubies would imply the extinction of the fire of our life, the end of our being, and thus does its sight inspires fear, ensuring that we would strive to interrupt its escape from us.

Fortunately, we are not alone in our strife for survival, as life itself toils to help us. The flow in our veins now carries more than the heavenly beasts, and in the event of a spilling of blood, a multitude of cells work together to seal the lacerated skin and flesh, to heal our wounded body. We may consider how often have these diligent servants of our body saved us from death, what we owe them.

Feeling the warm flux running through our limbs, we may recognize in it the blood of the earth, the fiery torrents of molten iron circling around the very center of the planet upon which we stand. Concentrating our attention on the air flowing inside us, we may notice that it continues its course in our veins, with blood carrying bits of the sky in the innermost parts of our body, in a flow as fluid as the winds above us.

Chapter 20

Discovering the Seas: Vision and Imaging

The light of the sun is already shining inside the world of the animals, having slipped through their eyespots, which are like small cracks through which the presence of the fiery star can be inferred, with the shape and contour of this source nonetheless remaining concealed. They have seen the fruits of the sun, but have yet to see it itself, and the fullness of the gifts that the gilded star offers to life. Their existence has begun to be paced by its daily rising and setting, but they have yet to witness the effects of its course on the earth, the sea, the sky, and the life flourishing between them because of its outpour of brilliance showering them all. Life nonetheless continues its relentless work of exploration of its own possibilities. It searches for better ways to employ the envoys of the sun, to take advantage of their gift, by letting minute changes occur with the passing of each new generation and the coming to being of each new animal, almost insignificant alterations to the eyespots in an attempt to make its relationship with the celestial orb more fruitful, more advantageous for the growth of the tree of life.

The eyespots of the marine worm, like the apple of our eyes, demand care and protection. The cells found on their surface are very sensitive to light, but they are equally sensitive to abrasion, collisions, and the myriad of ways by which the earth, the sea, and other forms of life can mistreat the body. At this point, such

an eyespot is still a mere patch of sensors forming a disk on the surface of the head, laid bare to the elements, without cover nor defense. As the creature burrows into the muddy floor of the sea, the sandy soil may scratch or lacerate these precious sources of information. As it fights against other members of its kind for food or a mate, the smallest blow may render the animal blind, condemning it either to death or to fail to bring forth an offspring. Perhaps because of these reasons, the eyespots of certain of these worms began to retreat toward the inside of the flesh. This feature was selected by life not only because it may have offered protection to the light-collecting cells, but also because as the depth of this retreat increased, it allowed the creature to perceive something new, to enlarge the crack through which light enters its world and to reveal a property of this light: the direction from which it comes.

The light-sensitive surface is slowly curved with the passing of generations, progressively turning into a hemisphere, opened toward the sea, with a bundle of nerves carrying the information collected to the brain (See Fig. 20.1, second image). At the scale of the animal, the light of the sun reaches its eye, appearing to trace a straight line through the waters, and with a planar eyespot, the light rays coming from any direction would be equally able to reach every single one of the light-welcoming cells. With the curved eye spot, on the other hand, this is no longer the case. The curvature acts as a sort of cave, which provides shade from the sun because the light coming in a straight line from the sky can no longer reach some of its parts. Even when the great luminary shines with all its brilliance, assaulting earth and sea with its myriad of envoys, it can no longer touch the upper part of the eye, which therefore remains mostly dark, simply receiving the scattered envoys reflected by the earthly objects surrounding the creature. The bending of the eyespot causes an occultation. Less light is received by it. This concealment nonetheless soon becomes the source of a revelation, as by inducing a distinction between illuminated and dark parts of the eye, a new dimension of vision is opened up to the animal. The perception of the sea offered to the creature is no longer a mere contrast between light and darkness, a single spot with varying shades of gray. It now becomes a two-dimensional image. Extremely crude, this image nonetheless offers something radically new: it shows the general direction of a source of light, such as the sun. The veiling of such a source of brilliance,

caused by the passing of a living thing through the field of vision for example, would also be a source of information concerning the location of this neighbor, allowing the animal either to avoid or to pursue it. By receiving less light, being more selective, the eye therefore sees more, and sees it more clearly, and this considerable advantage was therefore positively selected by life.

The curving movement of the light-sensitive surface, which was spread across many generations, nevertheless continued, because the narrower was the opening through which light reached the internal, sensitive surface, the more detailed and clearer was the image perceived by the animal. Through extremely small incremental steps, minute discoveries accumulated and preserved by selection, life began to discover the laws governing the propagation of light, *optics*. Its knowledge slowly progressed, and it soon found out that by almost completely curving the eyespot upon itself, shaping it into a sphere, only letting the light reach its now concealed surface through a narrow circular opening, a true image of what is present in front of the creature could be painted on it and passed on to the brain (See Fig. 20.1, third image). Eons after this discovery, man would claim it as his invention, better known as a “pinhole camera”, the first kind of apparatus used to take pictures of the creation. Life continued to optimize this discovery, finding an ideal size for the opening, one that would let enough light in and leave it unaffected by distortions, and also be sufficiently narrow to allow a precise image to be projected on the inside surface.

A major problem with such an eye would nonetheless be directly related to the narrow nature of its opening, the fact that anything entering the eye would likely remain there, obstructing the view or even damaging the eye. Filled with seawater, which freely flows in and out, the primitive eye would quickly be replete with sediment or even tiny lifeforms that would quickly make the creature completely blind, and render the eye useless. A relatively rapid selection must then have occurred, giving a crucial advantage to those who found a remedy to this woe. A transparent surface covering the opening of the eye emerged out of random mutations, insulating the inside of the eye, now filled with a perfectly transparent liquid coming from the inside of the creature itself, from the murky waters of the sea (See Fig 20.1, fourth image). The image perceived by the animal further gained in clarity and detail,

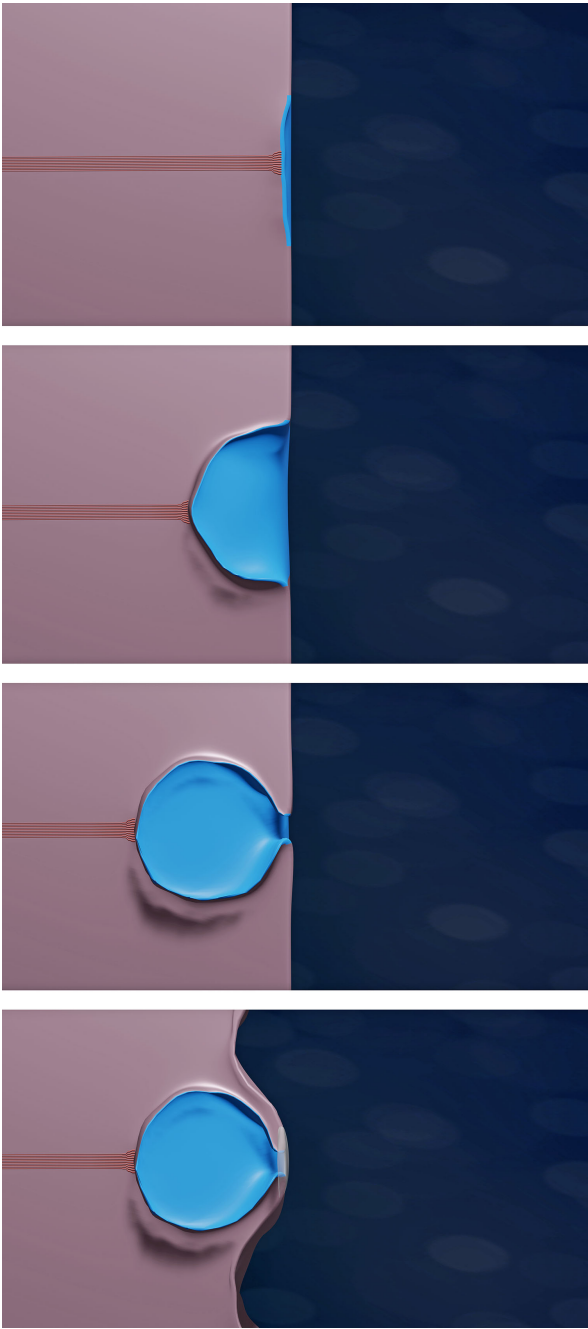


Figure 20.1: *From an eyespot to a rudimentary eye.*

and its eyes became less prone to infections, damage, or obstruction. All that remains to be discovered is the ability to change the size of the opening through muscle contractions and the role of lenses in producing sharp images focused on different distances, something that will nonetheless demand a considerable number of generations.

First came the distinction between light and darkness, day and night, and then was the source of almost all brilliance uncovered, the sky, in which the stars burn their own substance from within to shine throughout the firmament. The heavenly radiance first slipped into the animals' world through tiny cracks, only letting its presence barely be felt, as the surface of the eyespot was laid bare and flat, indiscriminately welcoming all light equally. As the eye was folded upon itself, becoming increasingly selective and discerning, letting through only a minute portion of the light reaching the creature, the light entering its world occupied an increasingly large and important place. The light of the sky is therefore different than the light of the world, as the dimming of the first induces an intensification of the latter, with the two directly correlated to each other. It is the work of life to find a way, the best way, to make use of the gift of the sky and to grow more intimate with the upper realm, so that it can lift up the veil that until now covered the sky, the sea, and the earth, and thereby become more acquainted with nature, more intimate with its forces, so that it may improve its capacity to survive, to adapt to an ever-changing environment, and to give birth to a new generation that will rise upon its shoulders, preserving the inheritance, the world, built by the sacrifice of countless of their ancestors, up to the great event that saw the kindling of the first spark of life.

The transition from mere contrast perception to true vision has profound repercussions on the life of our distant marine ancestor. A shift of its attention occurs as a result of the revelation induced by the emergence of the eyes, with the sky and the sun gradually losing their importance in the eyes of the creature as its ability to see its immediate surroundings improves. When it only saw a bright spot located on the top of the sea, this source of light was what had to be sought after and followed, but now that the veil covering the content of the seas has been lifted, the celestial brilliance is relegated to a secondary role, the one of a lamp bearer that illuminates its path. This depreciation of the heavens in the



Figure 20.2: *A marine worm with true eyes.*

eyes of the creature is reflected by a shift in their very position on its head (See Fig. 20.2), as they now face the sides of the animal, the sea, rather than face upward, toward the sky, as they were before. The creature knows not that this unveiling of the sea is a gift of the sky, and its attention is now constantly attracted, during the hours when the celestial bodies shine at least, by the countless things that now appear around its body. Other living things roaming nearby through the clear waters, sea plants gently waving with the currents, rocks and mud covering the floor, all these things that until now could only be felt with the skin, in very limited numbers due to the need for direct contact, now appear all at once, rushing into the animal's world like a torrent, filling it to the brim with innumerable things that now considerably enhance the precision of the representation of the earth and the sea that the creature has built into its world, inscribed within the nerve network concentrated in its brain.

The behavior of the seeing animal is deeply affected by the new sense. Able to perceive the presence of objects remotely, before they are within its reach, it can now rush through the waters without risking a violent collision. Less caution is needed when it roams the sea, and speed is once again selected as an advantage. The faster the creature is, the more likely it is to fetch a prey, to evade a predator, or to reach virgin territories. This selection shapes the body of the animal. A tail appears behind the excretory opening, facilitating propulsion and changes of direction.

Fins begin to form on the upper and lower part of the body, further increasing its agility and velocity. This new power nonetheless remains entirely tied to the benevolence of the celestial bodies that dispense their gift when they see fit. When the dark times come, together with blindness, the seeing creature is more than ever compelled to seek refuge, laying low in the velvety mud or in a crack of a rock, finding solace in sleep. Less attentive to the sky, it is nevertheless more dependent on it, as the bestowal of the gift of vision necessarily dulls its other senses and makes it less prone to venture into unknown places during the hours when the sun denies its radiance.

The celestial forces cleave the sea into two distinct domains, separated in time but continuously alternating, responding to the course of the sun and the phases of the moon. During the bright hours, the seeing animals occupy the front of the scene. Swiftly wading through limpid waters, they have a significant advantage over blind forms of life, which learn to retreat from the places where the envoys of the sky shine, through selection as they have no means to see it. Taking advantage of their gift, they can control a large territory, plunder the resources of nature, and stalk their prey with ease. The roles are nonetheless reversed during the dark hours, when the moon is veiled and the sun has passed through the horizon. Then comes the time of the blind ones, when they can venture outside of their lair, the abyss, the crevasses and the sediment layer, as the seeing ones are now blinded by the night and are forced to take cover, dimming their senses to explore their own world through sleep. Such separation is also extended through space, as seeing and blind creatures naturally find territories best suited to their nature. The celestial forces, by their continuous ballet displayed across the heavenly vault, therefore shape the distribution of lifeforms within the sea. They set up dominions and trace the frontiers between them, offering large domains to their proteges who are employing its myriad of envoys piercing through the sea, but nonetheless also leaving a portion of the waters to those who are more intimate with the earth than with the sky, the blind ones who rely on the senses of touch and smell rather than on vision.

The emergence of vision is nonetheless not a punctual event, but rather a progressive unveiling that was probably spread over a considerable number of years. A spot of light was slowly trans-

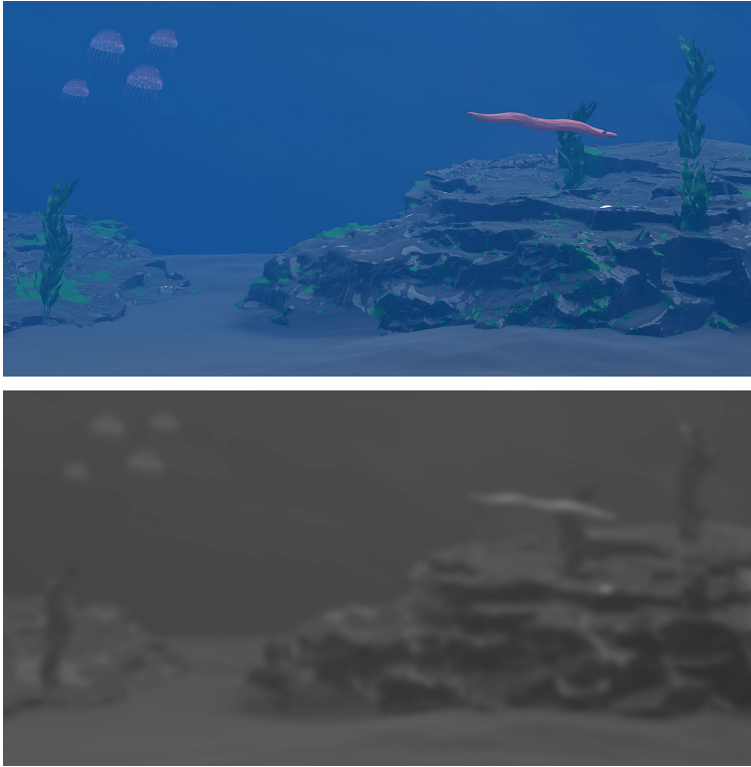


Figure 20.3: *The relativity of vision.*

formed into an extremely blurry image, which in turn grew sharper with the passing of many generations, as life favored those with the most discerning eyes. What the eyes offer is only a particular and subjective image of the sea, rather than a perfect representation of an objective reality. Each lifeform sees it in its own way, one that evolves together with the creature itself. At this point in time, it is unlikely that the first seeing worms would have been able to perceive colors. The positioning of the eyes, on the side of the head, would have made depth perception less efficient than ours, with the creature favoring a larger field of vision, more crucial to evade predation perhaps. What these animals saw in all likelihood would have been a monochrome, blurry vision of the sea, allowing them only to distinguish general shapes and movements, something nonetheless already invaluable, a mighty weapon in their struggle for survival and reproduction (See Fig. 20.3)

Vision profoundly changes the relationship that the seeing an-

imals have with the earth and the sky. It is a fundamentally heavenly sense, not only because it is the celestial bodies that allowed them to see in the first place, but also because it lifts them up, away from the earth, in the large sense of all matter, which is felt with the sense of touch. The seeing one can more efficiently explore and interact with the world of the sea using his eyes rather than his skin. He does not need to move by himself and touch things, as things are rather brought into his eyes and into his world, by the envoys of the sun, without effort or motion. He no longer needs contact with earthly matter for exploration, only for feeding and mating, increasingly relying on the visual representations built in his world, using vision as the main source of information. Furthermore, the eyes not only take the animal away from the earth and closer to the sky, but also allow the unveiling of new kinds of things, things that cannot be touched or experienced with other senses. Places that the creature cannot explore with its body, but which can be reached by light rays, can now be revealed. The presence of living things that are impossible to approach can now be perceived. The sky itself, and the celestial bodies that remain out of its reach, can now become part of its world. Assailed by a deluge of stimuli, changing at each instant and lasting for the duration of the bright hours, the animal is compelled to increase the pace of the building of its world. This cascade of information demands that this world be built on a larger scale, on a larger soil, which is the earthly network of nerves forming its brain. As the competition between kinds and individuals is fiercer than ever, those who are best equipped to take advantage of this increasingly large flow of stimuli are selected by life, leading to more intelligent and more reactive creatures.

Vision nonetheless remains entirely dependent on the purity of the water of the sea. Water represents a link between earth and sky, just like life itself, which was born in it, as it is a form of earthly matter, something that can be touched, but it also shares with the air its fluidity and with the sky its transparency. Contrary to the earth, which repels the intrusions of the envoys of the sun, the sea welcomes them, letting them illuminate the space in which life flourishes. Some creatures will nonetheless learn to drive a wedge between sea and sky, thereby rendering the animals relying upon vision to stalk their prey momentarily blind. The simplest example would be the way animals can deliberately muddy the

water by swiftly wading through the sediment layer covering the seafloor, projecting it upward and rendering the sea as opaque as the earth, allowing evasion under the cover of darkness. Some would later take such a measure into their own hands, or tentacles, by themselves secreting a cloudy liquid that would allow them to conceal their presence, like the octopus. Thus using the power of the earth against the work of the sky, this strategy shows that even without any consciousness by the individual animals, life may play an active part in the strife between earth and sky that occurs in the sea. Vision may have brought a part of life closer to the sky, but the earth remains strong, and the battle between the forces of nature continues, a battle that shaped and will continue to shape life as it unfolds.

Re-flection: The Light Within Us

As the first rays of dawn pierce through the foggy blanket of the earth, scattered by the dew, The light of our star illuminates our world, revealing the splendor of nature, bringing it to our eyes. Thus ends the night, the time when we are blinded by the darkness enfolding the sea and the land, and are left to use our hands to discover what surrounds us, reducing our horizon to our immediate vicinity.

Closing our eyelids, we may at all times plunge ourselves back into the darkness of the night, and let our mind be permeated by the realization of our helplessness and dependency on the guidance of the sun. What would our life be without this invaluable shower of light poured upon the earth from the sky? Life was born blind to its all-revealing radiance, which came before the planet itself, but a large part of it has been shaped by this luminous rain, with eyes serving as vessels of light.

Our remote ancestors first discovered the existence of contrast, the difference between light and darkness, as eyespots revealed the presence of the sun above the horizon or the movements of a creature nearby. The light shining within the animal world then grew more refined and precise as the heavenly wheels turned, transforming a white canvas into a sophisticated painting, with vivid colors and an infinity of hues.

Raising up our eyes toward the fiery orb hovering above the earth, letting its rays warm our face, we may be mindful of the role played by it in our life and our world, and the course of its rays. Radiated by this blazing sphere of molten matter, they travel through the darkness of the cosmos, before they reach our planet, in a few minutes, scattering as they bounce on the things of the earth. Standing in the way of these reflected rays of light, we collect them in the depths of our eyes, and from the patterns that they draw on our retina, we infer the presence of the things around us.

The gift of our star brings us closer to the sky, calling us to turn our face upward and reach out to it, but it also brings all the things present on the surface of the earth to our world and our attention. When we are bathed with brilliance, we do not need to touch things or people to interact with them. We can

make gestures seen from afar by others, and examine objects that are out of our reach, and thus light not only broadens our visual horizon but also extends the range of our actions on earth.

The wondrous nature of vision depends on light but also relies on the ingenious nature of our eyes, the fruit of a painstakingly lengthy work of selection by life and nature, refining it to perfection. Delicately touching with our fingertips the cornea covering each one of our eyes under our eyelids, we may notice how it protects them from the dust and the winds, preventing any dangerous intrusion.

Looking at our face in a mirror or another person, we may contemplate the beauty of the iris, and see how it instinctively contracts to reduce the flow of light poured through the pupil. The eyelashes shade the eye from the violence of the sun-rays having yet to be reflected on the earth, showing that we have been shaped to turn our eyes to the horizon, our world, rather than the skies.

We should nonetheless also take heed of the subjectivity of our vision, and thus of the world we build from it. The colors and strokes with which our world is painted are not the same as those of other creatures, and the pictures filling our mind, forming our world, are representations rather than objective truth. Countless are the colors and things invisible to us but visible by others, with each having its own gifts, and we may thus try to imagine the true extent of nature, what remains concealed from our senses.

When the celestial beacon blessing us with its guidance retreats beyond the horizon at dusk, and all that remains is the faint glow of the stars and the pale face of the moon, we are called to reflect. The gift of the sun granted us the ability to run through the surface of the earth, without fear, as we could see the obstacles standing in our way, navigate through them, and recognize our destination. Deprived of this brilliance, we may now turn our eyes to ourselves, our world, and let our dreams shine.

Chapter 21

The Hard Life: Vertebrates and Mineralization

As our marine ancestors were endowed with the ability to see the wonders and dangers of the sea, the world that they built, that is, the way they represent the earth, the sea, and the sky, swiftly grew in complexity and precision. As a result of this prodigious expansion of their world, their horizon was broadened, the competition between them considerably increased in ferocity and velocity, and they were thus pressured to become more reactive and slyer than their opponents. The fittest out-bred the ordinary, and the most skillful builders and dwellers of the world often were those who were at birth blessed with a superior, larger basis of this world: the network of nerves pervading their body. What was demanded of them was not an especially astute intellect but rather an aptitude to control their own flesh, their muscles in particular, with both precision and rapidity. This is why the movement of centralization that gave birth to the brain was followed by another, one that saw the growth of a thick cord of nerves along the length of the animal, which would help it achieve greater and more efficient control of the various parts of its body, one that would later be known in humans as the spinal cord.

The always greater need for energy in this highly demanding environment also led to the appearance of gills, allowing the crea-

tures to extract more oxygen from the water and to overcome the limits of absorption through the skin, and thus remove a barrier to the growth of their body. More energy means more sustained efforts, and thus a greater capacity to pursue prey and flee predators, with both under pressure to prevail over the other, leading to a virtuous cycle of evolution. This arms race and strife is the fertilizer that allows the tree of life to grow, increasingly beautiful and strong. The great battle taking place within nature nonetheless encompasses every single one of its components, and not only the middle realm, the life burgeoning within the sea. Earth and sky are still major players in the game whose field is the great expanse of water marking the boundary between them, and the place where the fruit of their union lives. The sky offered our ancestors the gift of sight, allowing us to represent the content of the sea without direct, earthly (that is, material) contact. Now, the earth will also offer a present to our forefathers, one that has been passed on to us, and thanks to which our body not only is a savant blend of soft tissue and liquids, but also has parts that possess the hardness of the earth itself: teeth, bones, and in the case of some of our ancestors, scales.

The story of this incursion of the earth into life nonetheless begins within life itself. As seen during our examination of sponges,¹ animals have since the birth of their branch of the tree of life known how to secrete a viscous and yet somewhat solid substance, collagen, that could provide structural support to the body. In the case of sponges, which had no compact tissue of cells, this frame formed the major part of the body, but their descendants learned to make a more specific use of this product of life. Combined with other substances, it is used to form cartilage, slightly rigidifying specific parts of the body. One of the places where such a rigidification would be the most advantageous certainly would be the mouth, as a cartilaginous jaw would considerably facilitate the biting and ingestion of food, especially if this food is alive and resisting its fate. From this location, the benefit of stiffness would naturally have spread a little further, through selection, to serve a different and yet critical purpose: the protection of the brain and the eyes, upon which the life of the creature entirely depends. A cartilaginous skull shelters the brain from the impacts caused by collisions with the earth or from the blows of predators and competitors,

¹See Ch. 1.14.

leading to a greater chance of survival and reproduction. Thus did this discovery spread among the population, as well as across the bodies of the animals. A subtle equilibrium had to be found, as the stiffness induced by the presence of cartilage in some places may prevent them from moving swiftly and precisely controlling their body. A balance between the benefit of protection and the need for flexibility was nonetheless found, leading to the emergence of a cartilaginous skeleton.

It is at this point in time that the earth offers life a new gift. The blood of the earth is then poured in great amounts onto the surface of the planet and into the depths of the seas. Large quantities of a rich variety of minerals found their way into the vast expanse of water sheltering and nurturing life, and as the play of love and strife, mutation and selection continues without interruption or abating, life discovers uses for some of them. One of the most remarkable of these is the use of various forms of calcium phosphates to harden the cartilaginous tissue that is used by them for protection or to tear flesh apart, transforming the collagen-based scaffolding into the enamel coating the teeth, the bone forming the skeleton, and similar substances in scales. These are three manifestations and three refinements of a single kind of reaction, by which the minerals offered by the earth, through the flow of magma and the movements of the terrestrial crust in particular, seep into living things, permeating the core of this branch of the tree of life, offering these creatures the hardness of the earth as a new weapon that they will wield in their battle against their own kind, against life itself, and against the other forces of nature that resist their expansion. The technical name referring to such an emergence of hardened parts of the body is *mineralization*. Minerals represent the bulk of the earth's crust. They are the rocky floor serving as the foundation of the soil and the sea, and they flow in molten form like underground rivers in the depths of the earth. Now, animals will learn to exploit this wealth of minerals poured into the waters, so that they can overcome the obstacles in the path of their evolution and their conquest of the sea.

The emergence of teeth allowed the animals to pierce through the skin of their prey as they bit them, tearing them to pieces by violently swinging their head left and right, and thereby allowing the creatures to ingest them. Furthermore, the appearance of a true jawbone improves the efficiency of biting. This combination

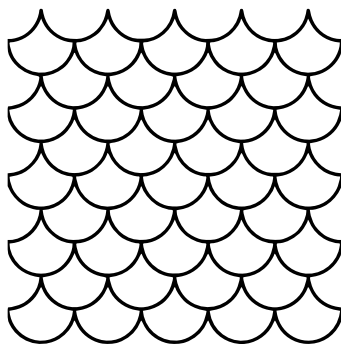


Figure 21.1: *A pattern of overlapping scales.*

changes the importance of the size of animals for the determination of who can prey on whom. Ferociousness now gains in prominence, as a sharp set of teeth, when used aggressively and skillfully, could allow a single animal or a group of small ones to vanquish and devour an animal considerably larger than them. They no longer need to scavenge the decomposed flesh of larger animals, and are no longer condemned to restrict their diet to what could fit into their mouth, whole. The hierarchy between several branches of life is therefore imbalanced, reshuffling the roles of each one of them and reinvigorating the species, inciting them to improve their fitness in order for them to survive and prosper.

The hardening of cartilaginous parts propagated, even though the order by which it occurred is far from certain. Teeth and scales are the most likely candidates as the first hardened parts, but the role played by either of them is so intimately linked to the other that such a determination is somewhat futile. Scales grow on the skin of the animal and are in their structure and composition relatively similar to teeth, even though they may appear radically different to our eyes. The advantage that they provide, which led to the selection of the individuals endowed with them, is to act as a suit of armor, protecting the flesh of the one wearing it from being pierced by the teeth of other living things. This armor is remarkable because of the ingenuity of its construction, very similar to those made by the hand of man, eons after its discovery by our distant forefathers. It represents an almost ideal compromise, an astute exploitation of the hardness of the earth combined with the softness and fluidity of the sea, as the regular pattern of overlapping scales, of the precise shape and adequate

size, provides a continuous cover without hindering the movement of the animal, as each scale is anchored on a single point on the flexible, underlying skin, and their flatness allows them to slide on top of each other without damage nor impediment (See Fig. 21.1). Like a rank of diligent soldiers in tortoise formation, these scales defend the body from attacks by a wide array of weapons, forcing predators to develop stronger jaws and more serrated teeth, stirring up the arms race between branches of life, the great strife that is the driving force of the flourishing of the middle realm.

The skull and the jaw then became bone, allowing the creature to crush the flesh caught by its teeth, sometimes even crushing the finest armor made of scales, while improving the protection of its most vital parts. The propagation of the hardening went further, as the cartilage protecting the nerve cord that goes along the length of the creature became a spine. This spine makes use of a similar compromise as the one used to form the scale armor, allying a set of repeating rigid elements, articulated around softer joints, allowing the animal to combine strength with flexibility, earth and water, to gain an edge over its adversaries in the strife for life (See Fig. 21.2). The hinges between the rigid elements still allow the creature to swim by undulating its body, which is a very efficient way of navigating the waters. Protuberances on this spine then formed ribs that would protect internal organs, and tail bones completed the skeleton. The elements forming the spine would later give their name to the branch of the tree of life known as the *vertebrates*, to which we belong. The first animals belonging to this branch would have appeared somewhat similar to worms and eels, but some of them soon evolved to become one of the most successful and pervasive kinds of vertebrates: fishes.

More than ever, the creatures incarnate a graceful union of the earth, the sea, and the sky, with life subtly combining the power of each realm to edify its ever-changing body. The emergence of vision brought them closer to the sky, but the hardening of their flesh took them back, closer to the earth. It also somewhat loosened their bond with the sea, as their bodies sacrificed part of their watery, soft nature to give more place to the hard earth. The forces of nature continue to strive against one another within life itself, in its very body, nurturing the tree of life with showers of sand, water, and light. The play of predator and prey, attraction and repulsion, love and war nonetheless ensures that an adequate

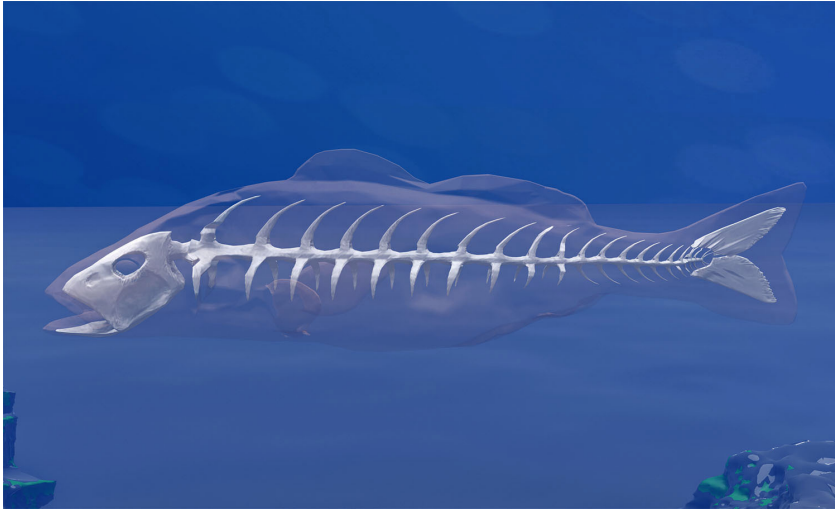


Figure 21.2: *A fish skeleton.*

balance is kept at all times, one that would fit a particular age and a particular location on the planet. The earth is hard and heavy, and this is why life only makes a parsimonious use of it. An excess of it would be an impediment rather than a strength. The waters of the sea are soft, ungraspable, and therefore an excessively watery body is poorly able to support strong and fast muscles, which need something earthly, hard, like a bone, to hold on to while they are contracted. Some creatures will nonetheless thrive through an unconditional alliance with the sea, such as mollusks, while others, like turtles, will put their trust in the hard earth, building their refuge, their shell, out of it.

One should nonetheless not think of teeth, scales, or bone as mere dead matter. These are tissues that combine what is dead and what is alive, life integrating bits of earth to exploit its strength. The bulk mass of a bone is made of dead, earthly matter, but this mass is formed around a scaffold of living cells, which first secrete a substance that is then mineralized, hardened, with the cells finally maintaining this structure for the rest of their existence, which may be as long as the one of the animal. These cells are organized in an intricate network, joined together by minute channels through which signals may be exchanged, but different types of them also have been assigned different roles. Some are in charge of secretion of the bony substance, while others can dissolve

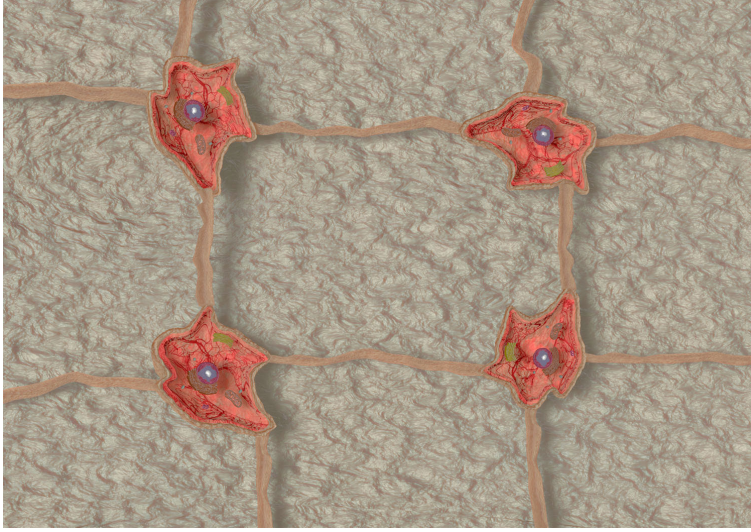


Figure 21.3: *One type of bone cells inside the bone matrix.*

it when needed, and finally, others act as sensors of mechanical stress and coordinators, orchestrating the continuous remodeling of the structure (See Fig. 21.3). This mesh of communicating cells allows the creature to attempt to find a remedy to one of the most obvious disadvantages that comes with earthly, hardened tissue: the risk of catastrophic failure of the structure, fractures that occur when the stress to which it is subjected is greater than the bonds between its components. In order for a successful repair to occur, however, the fractured surfaces must be joined again, something relatively easy to do for creatures like ourselves, who can rely on other individuals for help, to feed or be safe, but that would nonetheless be difficult for a primitive marine animal who would need to continuously remain on the move to evade predators and find its daily sustenance.

There is nonetheless one further role of the hardened substance, which demonstrates the incredible resilience of life and the wondrous nature of evolution. The skeleton is indeed not only a scaffold, a supporting structure, or a suit of armor. It is also the storehouse of minerals of the animal. Elements such as calcium and phosphorous are accumulated in great quantities in this hardened tissue, and when the creature is starved of such elements, which are used in more critical parts of the body, such as the

brain, specialized cells within this tissue are activated and begin to dismantle parts of the bones, extracting the minerals found in them and dispatching them where they are crucially needed. Life has discovered ways to prioritize the functions of the body, learning to sacrifice some of its parts so that the whole may survive extended periods of scarcity, times when the flow of gifts from the earth dwindles. Life would nonetheless soon make what is perhaps an even more remarkable use of the gift of the earth, one that would allow the animals to rise above most other branches of life, and ultimately depart from the nurturing watery womb of the sea.

Re-flection: The Earth Within Us

What is found above us is the ungraspable, the ether and the vast emptiness of the heavens, whereas we stand upon the hard earth, which can be touched and seized, embodying an alliance between both. Life is born in water, like us sharing the fluidity of the air and the weight of the earth, and while our watery nature is one of our strength, life sometimes also needs to be clothed with a rocky vestment.

If our body was entirely made of a perfect fluid, it would be scattered immediately and run into the dry earth, but if it was perfectly solid, the fire of life would not be able to set it in motion and consume it. The balance between fluidity and solidity, heavenly and earthly nature, is at all times pondered by life, and thus it explores savant blends of both to refine creatures and adapt them to their surroundings.

Pressing our tongue against our teeth, we may notice their remarkable, stone-like hardness, and compare it with the softness of our cheeks and lips, which allows them to be bent and stretched. These teeth have borrowed the minerals covering the crust of the earth to be turned into weapons against other beings, crushing and tearing flesh and plants to extract from them the essence that will sustain our body.

Our teeth would nonetheless be useless without the support of the skeleton to which they are attached. Touching our jawbone and skull, we may feel their rigidity and their strength, supporting our flesh, and as our hands pass on our head, we may be mindful of the protection it offers for our precious brain. The teeth are weapons made to attack, but the skull is made to defend, to protect this crucial body part, as our ancestors swam head-first through the murky waters, often encountering rocks, pieces of earth.

Our skeleton is an inheritance from our marine forefathers, which has evolved to be suited to our life, preserving the skull, jaw, spine, and rib cage of the fish while adding bones to our four limbs. Touching our spine and feeling it bend as the vertebrae are articulated together to form a flexible whole, we may notice the craftiness of life, able to ally the hardness of earth with the flexibility of water. This allows the protection of our spinal cord, without hindering our movements, and provides support to the

body.

The articulation of each one of our bones is a manifestation of the need for contrast in nature, the fact that the alliance of opposites is a motor for evolution and growth, a root of life. The rigidity of the bone can benefit a creature that knows how to marry it with the flexibility of flesh, and thus life has patiently determined the length of each one of them, and their location on the body. Each joint that we feel moving is the result of a diligent study, giving us an advantage.

Our bones are a gift of the earth, which came after the sky offered our fathers the one of vision, but one that also brings us closer to the lower realm, as the weight of these bones makes us susceptible to its pull. We should nonetheless remember that we may still be inhabiting the ocean without their support, as their earthly nature also allows the body not to be crushed under its own weight, flattened by gravity. Our skeleton embodies the dual origin of life, allowing us to rise above the surface of the waters, while at the same time keeping us close to the surface of the earth, preventing further ascension.

Hitting something with our hands, we may feel the power of the earth bestowed onto us by our bones, considering how it allows us to prevail over other creatures, hunting or fishing them before they are eaten. These bones are our most ancestral weapons, concealed under our skin, offered to us at birth, and if someone were to rob us of them, our life would probably end with this unfortunate event.

These armors and weapons wield the strength of the rocks and the earth, but they are also part of life. If we violently collide with the earth and feel our bones cracked, yielding to a superior force, the living cells within them will relentlessly toil to heal what has been wounded, to mend what has been cleaved. Remembering an experience of the healing of our bones, we may notice the fire of life in them, how they are more than a mere aggregation of earthly minerals but a part of our life and being.

Chapter 22

Between Sea and Land: From Fins to Limbs

If the fish are still to this day omnipresent in every corner of the oceans, it is because they are incredibly well suited to their environment. They reign over large parts of the waters covering the earth, and when their kind sprouted out as a specific branch of the tree representing all living things, they were one of the finest achievements of life. As they patiently extended their dominion, across millions of generations, a great variety of fishes also emerged, with bodies tailored to a specific time, and a specific region of the sea. Growing like an unborn chick inside an egg, life swelled within the waters, feeding on the yolk made from the union of earth and sky, matter and light, by the humblest forms of life, harvesters of sunlight. The sea, like the egg, will nonetheless soon be unable to contain the life growing inside it. Parts of life are beginning to touch the boundaries of what had been a nurturing womb to them, signaling that the time approaches for them to be born again, out of this womb and into a new realm, one that they will have to make their own.

The evolution of life never occurs with giant steps but rather minuscule changes, and a specificity selected for one precise purpose may soon be found to open up new possibilities. Perhaps because it helped them stir up the mud covering the sea-floor to cloak themselves in darkness and thereby evade predators, or simply because it allowed them to swim more quickly and efficiently,



Figure 22.1: *A lobe-finned fish.*

a few species of fish developed four lobed fins on the lower part of their body, symmetrically arrayed, with two on the front and two on the back (See Fig. 22.1). These fins had the particularity of being supported with bones, enhancing their rigidity and ability to bear loads. The location of these new bony protuberances is no coincidence: they are hard and strong because they are meant to be in contact with the earth below, the solid matter that forms the seafloor. It is not especially difficult to imagine a particular situation where such vigorous and sturdy appendices would offer a crucial advantage to the survival of the creature. Caught in extremely shallow waters, in which swimming would be strenuous or problematic, they would allow the fish to wade through the muddy floor, pushing the earth away and slightly elevating its body, until the safety of the depths would once again be reached.

The parents of life, earth and sky, nonetheless continue to play their role, watering the tree and directing the growth of its branches, including the one from which we originate. The embrace of the sky, the light and air enfolding the planet, may then have become smothering for the middle realm. The earth may have become parched while parts of the waters of the sea would have been taken to the air. The ocean may have grown saltier, less hospitable to old forms of life, and the coastal waters would have been

shallower. Countless creatures may have found themselves trapped between the tides, forced to escape death with the strength of their lower fins. Mercilessly selected by life itself, the fish that were the fittest in this new sea, reshaped by an ever-changing earth and sky, nevertheless survived and thrived. The causes are uncertain, but their effect is manifest. Reflecting the transformation operated on the sea by the earth and the sky, the flesh of these creatures underwent a series of profound but continuous alterations.

Living in the shallows, the part of the ocean where the waters exert the smallest influence, the animals are pushed to get more acquainted with both the upper and the lower realm. They are constantly in contact not only with the sea, which supports their body and their very being, but also are forced to become intimate with the earth and the sky. Confined inside a fine sliver of water caught between the infinity of the heavens and the unfathomable depths of the soil, they have little choice. Some of them would return to the depths but others, perhaps because of the lack of predators, remained in the shallows and slowly let themselves be shaped by them. Constantly stumbling upon the earth, their fins began to become limbs, which would ultimately become our arms and legs. It is there and then that the earth invited this evolution, transforming the fish into what now resembles a four-legged creature, one that nonetheless remains a dweller of the sea. If the lower part of the animal was shaped by the earth, its upper part would also undergo a transformation. Crawling on the seafloor, in the shallows, the creature would have few things to see below, but it would now frequently stumble upon the surface, the dividing line between sea and sky. It would then be faced with a new world, a new realm, filled with things that it has yet to understand, including both opportunities and threats, predators and prey. The change of medium, from water to air, would demand considerable adaptation, but those succeeding in this task would have swiftly been selected and would have flourished. Turned as much toward the sky as toward the meager layer of water through which they wade, their eyes moved upward, closer to one another, ready to observe the things above (See Fig 22.2).

The animal probably first only briefly peeked through the surface. As it did so, it encountered a new medium, the air filling up the sky. The animal itself would not have recognized this fact, but the creature then stumbled upon an immeasurable treasure,

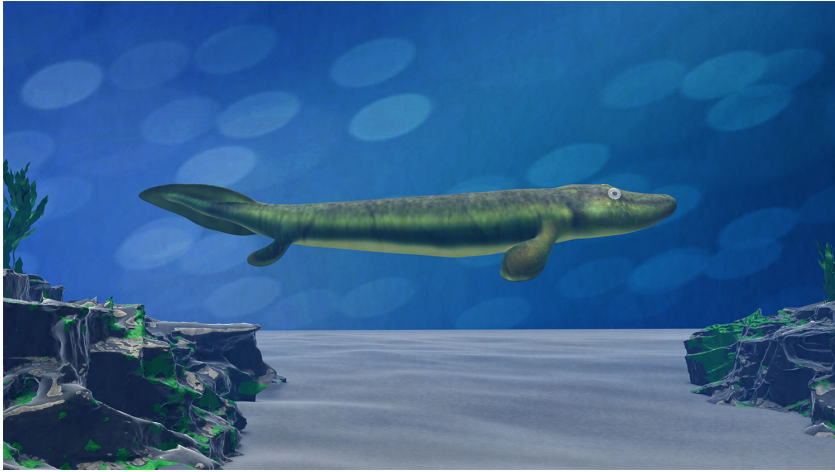


Figure 22.2: *A fishapod in the sea.*

the storehouse of the light-workers, which contained an extremely voluminous amount of energy in the form of oxygen, the molecular beasts that power many reactions of its body, concentrated in far greater quantity in the air than they are in sea-water. The fruit of the tireless work of countless generations and an astronomical number of living things is kept there, in a space offered by the sky, but nonetheless kept close to the earth through the agency of the pull induced by the rivers of molten iron flowing at the center of the planet. Preserved by the earth and the sky, this wealth is now offered to the animals who peer through the surface, cracking the shell inside which they spent the first stage of their existence. At a later point, the descendants of these creatures, animals walking on the dry land, will learn to exploit this treasure filling up the sky, transforming an organ that was filled with air, probably for buoyancy at first, into the lungs that would allow them to supplement their gills and consume far more of this precious resource of life. The four nostrils of our marine ancestor, found on its side, would then be reduced to two and move inward and up, close to one another, thereby improving its capacity to breathe.

The wealth stored in the sky is the inheritance of the animals, primarily the work of their distant forefathers but a work that still continued during all the subsequent eras of the history of life, with the light-workers still toiling and releasing their product to this day. The humblest creatures still more than ever support the larger

and more complex ones, which are fewer in number but demand far more resources and assistance. The four-legged animal nonetheless now also needs to support itself, literally, more than any of its ancestors. As it is progressively weaned from its dependency on the waters, the creature is indeed increasingly confronted with one of the powers of the earth that until then remained largely hidden and inconsequential: the pull of the earth, gravity. This invisible force is already linked to the appearance of its four limbs now used to wade on the sea floor, but the shallower the water, the greater is this pull to which all earthly things are subjected, as part of its body finds itself out of the water. This induced a pressure on the common ancestor of the four-legged animals, the lobe-finned fish that first ventured and dwelt in the shallows, one that would lead to another transformation.

The body of the lobe-finned fish is rather narrow but elongated vertically, an ideal shape to swim in the depths, by beating a tail horizontally. The waters of the ocean then support the body on its sides, making the pull of the earth almost imperceptible. This support is nonetheless slowly withdrawn as the creature occupies shallower waters, inhabiting the coastline. As the pull of the iron core makes itself felt by the animal, its vertically elongated body becomes a hindrance. As its body is barely covered by the waters, the fins that will soon become its legs are insufficient to support it. Balancing left and right, its movements are impeded, and thus those whose body is less vertically elongated have an advantage and are slowly selected. A considerable number of years of such a selection would then change the shape of the creature, turning the direction of its elongation, from a vertical to a horizontal one, from one that is turned toward the depths of the sea and the heights of the sky to one that is parallel to the earth. The animal lets itself be subjected to the pull of the earth, and lets its flesh be pressed against the soil, flattening it and aligning it with the horizon, the curvature of the earth. The four legs then become four points of contact, allowing the animal to combine the mobility offered by what remains of the support of the waters with the stability offered by earth. The ribs are enlarged, compensating for the loss of support from the water, as the creature slowly learns to grow more independent from the forces of nature that nurtured its life until now.

The visits to the surface then became more and more frequent,



Figure 22.3: *A fishapod on land.*

as the animal got more acquainted with the earth and the sky, while the sea receded from its world, like a changing tide. Its body became increasingly fit to depart from the waters, breathing the air of the heavens with both its skin and what would become its lungs, while it crawled on the muddy floor. As those with the strongest front legs were selected, one day came a point when one of them performed a feat that had yet to be accomplished by another member of the vertebrate branch of the tree of life. Either drawn by a desire to escape from the water or by a longing for a new dominion and its resources, this marine titan wielded all its strengths, extending its limbs as far as it could and contracting its muscles with all its might, to extract itself out of the ocean, setting “foot” on the dry land, thereby opening up a new world for its kind (See Fig. 22.3). This first step was not immediately followed by an exploration, as its limbs were probably too weak to allow it to drag its body far on the dry land, but it nonetheless was a prodigious achievement.

Other forms of life already began to occupy the new territory. Small fern-like plants flourished on the rocky landscape, with more rudimentary forms of life like mosses and fungi also covering the most hospitable locations. Some animals such as insects had already conquered vast parts of the dry land when the first vertebrate set foot on a shore of the dry land, but the discoveries made in the sea by its kind, whose knowledge is embedded in its library of information and expressed in its very flesh, will soon prove to give

this late-comer a series of advantages for a life on the dry part of the earth that others will not have. This new world is therefore far from being a virgin wasteland, and this may be one of the reasons explaining why the marine creature would be enclined to leave its original marine habitat to explore it.

It is probable that the emergence of the four-legged creature from the sea and onto the dry land is the result of a conjunction of events. On the one hand, the sea became less attractive, perhaps because of its weak capacity to store the chemical beasts powering its body, or maybe because an increased salinity of the water would have made it less hospitable to life. On the other hand, while the creature was pushed out of the water by the sea itself, under the influence of the earth and the sky, the land may have lured it in. The movement would nonetheless be long in the making, as this animal would not have been able to sustain itself on land without the prior arrival of "producers," living things capable of exploiting the force of the envoys of the sun to fabricate the building blocks of life. The absence of large predators would have been enticing to the four-legged creature, caught in a thin layer of water from which escape would have been difficult. The aforementioned insects and later plants would in time provide a source of sustenance, and the storehouse of heavenly oxygen would considerably increase the supply of energy for its body. The sea therefore pushed it out while the land pulled it in. For now, the creature nonetheless remains a visitor on land, crawling on its face only for brief periods of time, as its body is still in dire need of closeness to water.

The skin of the creature is indeed still poorly adapted to the dryness of the continental air, to the raw strength of the sun's rays, which was usually dimmed by the waters, or to the abrasion of the sandy winds. It needs to be kept moist, and it cannot wait for infrequent downpours from the sky. It needs to stay close to the watery womb that has always nurtured its being, up from its most distant ancestor, the first spark of life that shone inside the sea. It carries with its body a relatively large quantity of water when it extracts itself from the sea to venture onto the dry land, but the forces of the sky are quick to claim this water as their own, pounding the skin with light and winds, a skin that is at this point different than ours and more like the one of a frog, a watery surface of the body that lets moisture escape almost without resistance rather than a sealed pouch that would serve as a barrier between

life and the sky, the body and the air. It thus plunges back in the ocean regularly, finding solace inside its primordial home, and lets the minuscule soldiers of the sea once again run to fill the interstices covering its skin, initiating the healing of the invisible wounds caused by the earth and the sky. Going in and out of the sea, plunging itself into water and then crawling over the earth while bathing itself in the content of the heavens, it begins to wage a war against both land and sky, with the ocean as its ally and refuge. It strives to resist the aggression of the earth, the onslaught of the rocks, the sand, and the dust, which invade its lungs, scratch its skin, or cover its eyes. It battles against the sky, which burns the animal's coat with its heat, blinds it with blazing radiance, or chills it with icy winds. It nonetheless bravely struggles, generation after generation, slowly learning and letting its body once again be shaped by these forces of nature. This battle will be waged for millions of years, as it demands a great number of discoveries. Life, however, has all the time that it needs.

For now, the creature nonetheless patiently struggles. One of the most essential bonds that remain with water, and one that would prove to be difficult to sever, is the role that it plays in reproduction. Its eggs are like those of a fish, soft and unprotected. They need to be laid in the water, and would not be ready to survive the assaults of the land and the air. This is one additional reason why the animal will not be able to depart from the liquid womb from which it came. The waters will remain a refuge where its young are reared and where it can rest when the challenges of the life on the dry will prove to be too much. Even with a body that is far sturdier than the one of its purely marine ancestors, it will indeed rapidly exhaust its strengths each time it passes the threshold of the land, the surface of the sea, and enters the domain of the earth, where its vigorous and yet invisible pull reigns supreme over all things. The homecoming into the sea will therefore always remain sweet. The embrace of the waters is like the one of a tender mother seeing a long-departed child. The sea supports every part of its body and carries it, allowing the one returning to enjoy an almost absolute freedom of movement, with few efforts and few constraints. This joy of the homecoming to the ocean, the pleasure of being enfolded with the liquid of life and freed from the smothering force of the earth, will nonetheless endure, and it may explain why our own kind, even hundreds of millions of years

after our departure from the ocean, treasures such homecomings and men are filled with joy at the mere sight of it, eager to once again feel the embrace of the waters on their skin. Life nonetheless has called our ancestors to leave the womb, as a step toward adulthood. Only one who has departed may indeed know the sweetness of the home.

Re-flection: Our Limbs

The face of the ocean is a frontier separating the dominion of the swimmer from the one of the walker. This ocean is a space where life is enclosed in water, considered part of the earth because of its weight, whereas what is above it is heavily pulled down, to take it back inside the great body of the earth. Having crossed this Rubicon, our ancestors took a stand against the earth, seeking refuge in the air above.

Our skeleton, made of the dust of our planet, allows our flesh not to be crushed by the pull of the earth, but we would be paralyzed without our arms and legs, allowing us to not only resist but also to oppose it. Watching the fins of the fishes, we may see in them the source of these invaluable tools of our kind, as life shaped our limbs from similar protuberances, patiently extending and fortifying them.

Immersing ourselves in water, we can feel our weight become insignificant as we are carried by the liquid of life. Moving our limbs, we navigate this watery space, liberated from the oppressive pull of the planet. Swimming forward in the shallows, we may notice the weakening support of the waters, the return of our heaviness, and observing or touching our torso, our shoulders, and our hip, we may notice their broadness. They were flattened by life as a mark of submission to the earth, as our ancestors occupied these shallows.

Lying on the floor and slowly doing a push-up, the feat of our ancestors emerging from the sea becomes clear, as we feel the weight of our body pulling us downward while we exert our muscles to rise above the surface. Only when we lie flat on the floor, exhibiting a total submission to the chthonic force, can we rest. With a large part of our skin in direct contact with the earth, we trade mobility for tranquility.

We have been either lured by the safety of the land and pushed out of an ocean that became inhospitable, but now, life has given us the means of opposing the earth to walk over its face and make it our home. Crawling on the floor using our four limbs, we may imagine how our bloodline extracted itself from the ocean, and how the fins slowly turned into hands and feet, allowing the body to elevate itself above the surface of the earth.

The end of each limb represents a point of contact with the ground, a pillar supporting a structure. Being reduced to a minimum, the surface touching the earth ceases to be a hindrance to our movements, as we can easily move the rest of our body through the air, without friction standing in our way. Three points of contact are enough to be stable, leaving one limb free to move without imbalance, and thus life found a way for us to outsmart the earth, even later further reducing these points of contact.

Rising up on our feet, walking around effortlessly, we may savor the wonder of our inheritance, standing erect upon the earth, our body pointed toward the skies, uniting both realms in perfect harmony. We may observe the countless animals roaming the earth, sharing with us this wisdom of life, as they all crawl and walk on the ground, each using its own way of resisting the call of the earthly core.

Certain branches of the tree of life nonetheless embrace a closer relationship with the lower realm, like the snake, which abandoned the limbs of its ancestors to slither on the ground with its elongated body, injecting its prey with its venom and thus bringing many creatures, even men, back to the earth. Observing the birds perched on the roofs and trees, we may also witness another feat of life, and may see ourselves humbled by the vision of their soaring through the clouds, going where we cannot.

Seeing our arms and legs, how they allow us to conquer the surface of the earth and the seas, we may also consider what have we done with this remarkable power bestowed by life upon us. Each time we rise, resisting and opposing the pull of the iron core, what is our purpose? We are the sons of earth and sky, and perhaps we should be mindful of our relationship with both.

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Part II

Out Of The Water

Chapter 1

New Realms for Vertebrate Life: The Land and the Air

Our vertebrate ancestors are now about to depart from the womb of the sea, which nurtured them and their parents from the instant when the very first spark of life was kindled. Many of their cousins will continue to enjoy the safety and stability that it provides, but they are called to explore, to conquer, pushing the limits of their bodies to rise above their peers, both literally and figuratively. The shell is cracked and the creature inside it is ready to discover what lies outside of what had been its home until then. What is found when it passed through the surface of the waters is a new realm that offers more freedom but less support than the water, although it shares with it its fluidity and generally transparent nature: the air. The animal will nonetheless not inhabit the heights of the sky, or stand on the air. It will indeed be plunged in it, but as it pushes on its limbs to leave the watery womb, it crawls on another realm, the dry land, which will soon become its new home. The transition, the journey of exploration of our distant forefather, leads it to pass from a life in the sea, where it navigated freely across three dimensions inside a mass of water, to one combining the land and the air, a life on the surface separating these two realms, with few occasions at first to depart from the two-dimensional plane marking the boundary between

them.

The dry land and the air represent a new world to the animals, which will have to be contemplated, observed, and grasped if they are to survive and prosper in them. They will have to let the dry land and the air shape their flesh, in the same manner as their ancestors let the sea form what is now their body. Their nature will reflect the ever-changing flow of the sky and the earth, as like the sea before, the air and the dry will be constantly changing, albeit at a pace that will render these changes only noticeable across many generations. In order to see more clearly the nature of the shock that the conquest of the land represented to our ancestors, these two realms will therefore first be briefly examined. The attractiveness and the peculiarities of the dry land and the air will show why life felt itself driven toward them, and they may lead us to perceive their role in the great play between the forces of nature, and in our very life.

1.1 The Land

The great body of the earth takes its shape from the alliance of its spin and the pull of its own weight, which keeps it compact, producing a slightly ovoid sphere. Its surface is nonetheless rough, as the different elements and substances forming its crust possess a different capacity to resist being crushed by the pull of the earth or flattened by its spin. Set in a slow but continuous motion, the crust forms a series of plates that collide or are torn apart with the passing of time, and each one of them represents a unique pattern of highs and lows, mountains and valleys, painted with a large palette of materials, each with its own hue. The great sea enfolds most of the surface of the earth, but portions of it nonetheless stand out from them, protruding from the water and in direct contact with the sky: the land.

The land is the parts of the surface of the earth that are not submerged by the seas. Contrary to the muddy seafloor, it is constantly face to face with the heavens, scorched or warmed by the sun, scratched or caressed by the winds. It is rock and dust, hot while the sun shines and cold when it has retreated under the horizon. The land is nonetheless not always a desert, as the sky

parsimoniously redistributes some of the water that it steals from the land and the seas.

There is no form of life on our planet that does not depend on water. Before life can enter the dry land, water must first pave the way, bringing moisture to the arid continents, alleviating the thirst of the barren landscape. It is the most fundamental fertilizer, and the heavenly forces assume this role of water-bearer and farmer, relentlessly taking up prodigious amounts of the translucent liquid from the sea, purifying it, leaving behind all the minerals dissolved in it, and carrying it in the form of clouds where the sea is absent, deep into the continents, above to the highest peaks. They extract the moisture found on the skin of the ocean, especially during the day, when the sky is clear, devoid of any cloud, and the sun's envoys strike it directly, with the winds collecting and carrying their booty to the heights.

Once the heavenly vaults begin to overflow, water is showered indiscriminately upon the land and the sea, but with a generosity varying according to the time and the place. Parts of the land receive brief showers of droplets while others are blessed with unceasing downpours flooding their face and soaking their skin. No matter whether it falls on the summit of a mountain or in the depths of a canyon, this water nonetheless quickly runs down toward the lowest point that it can occupy, letting itself be guided by the pull of the earth. Here does one of the major differences between land and sea becomes manifest: contrary to the hard rocks forming the earth, water does not resist. It flows following the easiest path, letting its mass be flattened by its weight. It therefore hastens to run over the rocks, with parts of it occasionally mingling with the dust before being taken back to the sky under the influence of the envoys of the sun, and unless insurmountable obstacles completely block its way or the cold winds turn it to ice, it will end its course by returning to its home, the great expanse of water forming the ocean, until it is once again taken to the sky for a new journey.

The work of the celestial water-bearers leaves visible traces on the face of the land. The water that they pour on it forms convoluted networks of rivers, which at first, before life colonized this territory, formed braids on the earth rather than meandering streams, as the riverbeds were rocky and sandy, without soil or



Figure 1.1: *A braided river (Photograph by Geoff Leeming).*

mud that would force them on a particular path (See Fig 1.1). Each one of these braids nonetheless represents a track that life will be able to follow as it explores the land, going against the flow of the waters.

The land therefore marries the dry and the wet, earth and water, but both nonetheless remain largely distinct in this new realm. The sea also allied earth and water, but it did so in a different way, and the relationship that life will have with the land will differ from the one it had with the bottom of the sea, the place where it meets the earth. The seafloor is always permeated by a large amount of water, turning the layer of sediments originating from the erosion of rocks by the currents or the cadavers of formerly living things into malleable mud. Under the influence of the water, it becomes soft and silky. Creatures can penetrate it without strenuous efforts, using it for cover. Contrary to the seafloor, the dry land retains a purely earthly nature, only seldom adulterated by the rains. The land is hard, rigid, and difficult to penetrate. At first, when the earth was young and life had yet to coat its face, it was a rocky wasteland, without the sooty soil in which plants now grow, as this soil is itself a product of life. The first rudimentary living things that conquered this land encountered a habitat that was hostile to life. They faced the danger of desiccation at all times and had to take refuge from the wrath of

the winds, the assaults of the envoys of the sun, and the riverbeds provide such protection and nurturing.

As the resources offered by the land were at first very scarce, and the adverse conditions posed significant challenges, the first pioneers having explored the land were in all likelihood the light-workers, primitive forms of life that harnessed the energy of the envoys of the sun to turn death into life, building up its building-blocks from readily available substances, on the earth or in the air. They probably first made their way inland through the rivers, but their dominion was soon extended thanks to the rains, which formed lakes, ponds, and puddles where the light-workers, carried by the currents and the winds, could then settle. Life thus slowly conquered the land, starting with its humblest and most diligent members, sent as a vanguard that would continue the work of the rain, paving the way for higher forms of life. The ochre face of the land then began to be colored with touches of an emerald hue, as the light-workers became more numerous and their territory soon covered all the places where water flowed in sufficient amounts (See Fig. 1.2). The toiling of the light-workers was as patient and useful as it was during the infancy of life in the sea. Their work indeed was not merely limited to their own edification, their survival and reproduction. As it was the case in the sea, these feeble but wondrous creatures served the whole of life, as much by their life as by their death.

The light-workers spend their entire lifetime turning death into life, forming the complex substances powering their own machinery from rudimentary molecules, but even once the fire of life has been extinguished within their body, the product of their hard labor is nonetheless not lost. The building-blocks of life that they created remain, as the living thing is slowly decomposed by the elements. Cell walls then crumble. The entire machinery within them breaks down, and the long chain containing their library of information is ruptured in countless places, becoming a pile of single links, an unordered heap of characters that once were used to carry meaning but now have lost their signification. What remains is nonetheless far from worthless. It represents a storehouse of building blocks of life, which can be used to support the living. These residues of life will accumulate very slowly, with each generation of light-workers contributing to the edification of this storehouse of building-blocks of life. This wealth coating the land is

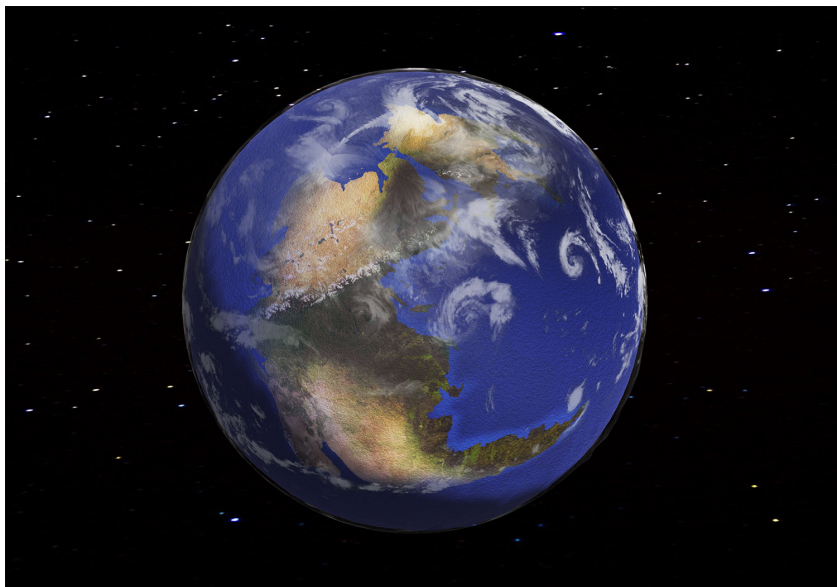


Figure 1.2: *The dry land of the early earth, with the Pangaea continent (long after the conquest of the land by vertebrates).*

soon exploited by new species, and new branches of the tree of life begin to sprout, branches of living things specifically adapted to live on land. Branches are even intertwined, leading to the birth of lichens, which are the result of the symbiosis of a light-worker with a fungus. These lichens nonetheless not only exploit the envoys of the sky and the remains of their cousins but also are endowed with the ability to break down the surface of the hardest rocks, extracting the minerals they contain for their own use. These minerals in turn find themselves mingled with the wealth of the light-workers that covers the face of the land, contributing to its variety. As life on land uses resources from the sea, the earth, and the air to turn death into life, the mass of this storehouse of building-blocks of life only increases with time, forming a key component allowing higher forms of life to depart from the sea and move inland: the soil.

The soil is to us often synonym with “the earth,” but while it is indeed made of earthly matter, it is also mainly composed of the remains of formerly living things. The soil under our feet, the layer coating the rocky surface of the planet and out of which most of our food comes from, is a mantle of decomposing and decomposed

life, the cadavers of our distant ancestors and cousins, who have offered their bodies so that the fruit of their work of edification of living matter would not be completely lost. We stand upon the bodies of our forefathers and are sustained by the inheritance we received from them, the soil, treasure of earth and life. Once this soil began to form, complex forms of life, such as large algae, could progressively move on the continent, learning to retain the moisture inside their body and to extract both water and nutrients in the newly formed layer coating the earth. The marine algae that occupied the shores and the riverbanks slowly evolved into plants, taking roots in the depths of the soil while their arms grew more and more extended toward the sun.

The soil then grew in height as well as in width, and soon covered a large portion of the land. Contrary to the hard, rocky surface of the bare earth, the soil is relatively soft and permeable. It absorbs and stores large quantities of rainwater, which is thereby made available to the lifeforms living on top of it. Once life had a sufficiently strong foothold on the land, and large parts of the landscape turned green, the first animals then began to crawl out of the waters to invade this new world. This vanguard nonetheless was composed of our distant cousins rather than our ancestors, who at the time still were roaming the seas. They were insects and other creatures endowed with hard limbs and outer skeletons: the so-called “arthropods,” among which scorpions and millipedes are found. These animals were the first to learn how to overcome the challenges of a life on the dry. Their armor-like skeleton prevented desiccation, and they adapted to a diet mainly composed of plants. Growing more imposing and pervading, the vegetation continued its conquest of the earth, often rendering the lower realm almost invisible from above the surface, as all that could be seen was the emerald coat covering what was not flooded by the waters.

In the sea, the liquid that allied earth and sky, the dark and the bright, life grew in patches, found scattered at various depths, nurtured by it. Life never dominated the sea, and mainly played a passive role in the relationship between earth and sky. Emboldened by its conquest of the land, and the progress that it made in the exploration of the possibilities offered by its evolution, life nevertheless grew more confident. Under the influence of the celestial forces, which started this movement of life out of the sea and into the land by showering the dry with the content of its vaults,

life indeed began to cover the earth, first with light-workers, then with soil, and then with plants and animals. The almost continuous nature of this soil, covering large parts of the land, caused life to drive a wedge between earth and sky, keeping them apart as it occupied the surface between both. It is as if the sky used life as a buffer and as a tool to rein in the influence of the lower realm. Life nonetheless followed the guidance of the sky, and covered the earth with its emerald vestment, hiding the roughness and bareness of the earth under beautiful displays of leaves dancing to the tunes of the winds.

The invasion of the land by life, which will culminate with the arrival of our vertebrate ancestors, is thus the result of a series of successive waves, mirroring the hierarchy of the living, according to the way they sustain themselves.¹ It begins with the pouring of fresh water upon the land, by the sun and the winds, and continues with the appearance of the producers, the light-workers. From the humblest to the pinnacle of life, the vertebrates, life thus proceeds with its invasion, with the foot-soldiers coming first, and the elite coming last. Life is helped by the sky for this conquest, but it may also be seen from another point of view. The earth indeed also benefits from this advance of life, as the soil also belongs to the earth. It is death supporting life, earth storing water and nutrients to feed its fire. The emerald coat also protects it from the onslaught of the breath of the heavens or the scalding heat of the fiery star. The rocky floor is preserved from being weathered by life, which endures the wrath of the sky as well as benefits from its blessings.

The strife between the forces of nature was therefore rekindled by the incursion of life on land, but life itself would at this time also turn out to be the cause of its own (temporary) demise. Unrestrained, the conquest of the dry by the plants continued and, inspired by their successes on the earth, they turned their attention toward the realm facing it: the sky. Plants then grew in height, elevating themselves toward the heavens, occupying an increasingly larger portion of the celestial dominion. Competing against one another to harvest the precious luminous showers offered by the sun, which sustain the fire of life within them, they strove to extend their arms above those of their neighbors, leading to a se-

¹See Ch. 7 of the first part of the present book.

lection of taller plants. Bushes and ferns gave place to the most majestic of the plants: the trees. The landscape was durably and profoundly transformed by this emergence, as the canopy formed by the forests opened a new space where life could develop, sheltered from the wrath of the sky, one that would later prove to be a refuge for our ancestors. This uncontrolled growth of the forests nonetheless also proved to be a danger to many other branches of the tree of life. Covering large parts of the land, the forests indeed consumed an enormous quantity of carbon, extracted from the air by the plants and turned into building blocks of life. The carbon dioxide present in the air nonetheless also plays a crucial role in keeping the surface of the earth warm, by absorbing the envoys of the sun that are reflected by the earth and the sea, preventing them from returning to the depths of the sky. An excessive growth of the emerald canopy, eating up this invisible warming fur of the earth, therefore apparently led to a relatively brutal cooling of the earth and the air, so rapid that many forms of life, in the sea in particular, did not have enough time to adapt to this change and became extinct, their entire branch cut off from the tree of life. Life nonetheless recovered and adapted. An equilibrium was found between the forces sharing the surface between earth and sky.

Our marine ancestors nonetheless did not only step on the land when they emerged out of the sea, they also were plunged in a new fluid, which would fulfill many of the roles played by the sea during the infancy of the vertebrates: the air.

1.2 The Air

The air is the inconspicuous fluid enveloping the earth, forming the unseizable substance of the lower skies. To the creature coming out of the body of the sea, the heavens may appear empty. Only when a breeze blows on its skin can the presence of the air be felt, as the eyes cannot discern its nature. What the eyes see is not the air itself but rather the vastness of the firmament, the infinity of the heaven, the splendor of the celestial luminaries, and thus little attention will be paid to the ether enfolding the land and the life above its surface. Contrary to the sea, in which the profusion of things carried by the water severely limited the horizon of the

animals, the transparency of the air offers them a full view of the extent of the creation, unimpaired by impurities, crystal clear and unclouded. Only when the heavenly forces mark their presence through sporadic displays, such as rain, hail, or fog, will their vision be limited, their horizon shortened. Even with a perfectly transparent blue sky, the heights of the heavens nonetheless also differ from the sea by their inaccessible nature. Crawling on the earth, pulled against the surface by the heaviness of the iron core of the planet, the first vertebrates will for a long time remain prisoners of the surface, only soaring in the heights in their dreams. This is nonetheless not the case for all branches of the tree of life.

Insects have indeed already begun to conquer the air when our first ancestor set foot on land. Their relatively lightweight and minute bodies allowed them to elevate themselves and navigate in the heavenly fluid, pushing it down with their wings to counter the effect of the pull of the earth. The air and the winds can also carry the smallest forms of life, single cells, to the four corners of the earth, sowing seeds of life on the entire surface of the globe, with many of these seeds forming new colonies, paving the way for higher forms of life.

The air is nonetheless more than a transparent window allowing animals to see the creation. The whole of life on land also rests upon this thin layer of air enfolding the earth. The carbon forming the frame of the plants is indeed not extracted by their roots from the depths of the soil but rather taken from the air by their leaves. The bulk of the matter forming the emerald coat covering the land does not come from the earth but from the air, which contains an invisible to the naked eye but yet very much present treasure-house of substances crucial to life. Stored in the form of carbon dioxide, it is readily available everywhere the blind blows, everywhere the air can seep in, down to the darkest cave inaccessible to the radiance of the sun, allowing life to flourish on the entire surface of the land, at least potentially. The air nonetheless also stores the wealth of the light-workers, the product of hundreds of millions of years of tireless work, offered as an inheritance to life as a whole: the minuscule chemical beasts whose strength is harnessed by many lifeforms, powering their body, that is, oxygen. These molecular beasts are present in the air in far greater quantities than in the sea, today representing around one percent of the content of the seas but more than twenty percent of the air.

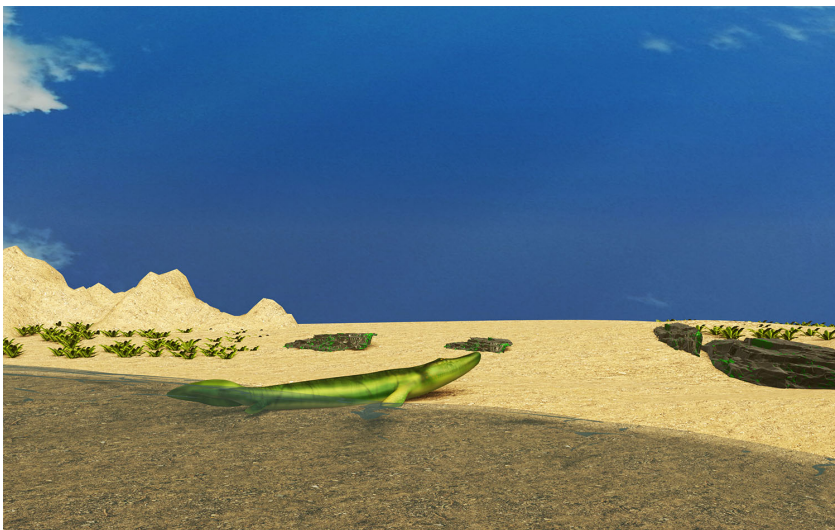


Figure 1.3: *The sea, the land, and the air.*

This would allow life to consume more of it, and therefore grow to larger proportions, with greater bodies, faster movements, and more endurance during efforts. Finally, another substance, which is the most abundant in the air, is also exploited by life: nitrogen.

As seen in a previous chapter,² nitrogen is an inconspicuous and yet important element to life as a whole. Thunderbolts regularly transform large quantities of nitrogen gas in the air (N_2) into compounds such as ammonia (NH_3), which can be used by life, but for the most part, this work of transformation is performed by different species of single-celled lifeforms, nitrogen-eaters (*Diazotroph*). Often living in the soil, near the roots of plants, they diligently serve them, “fixing” the nitrogen of the air into compounds that can be processed by plants, turning the wealth of the air into life.

Life is thus truly a child of the earth and the sky. It is sustained through the almost miraculous conjunction of all the forces of nature. Even the air, whose essence is hardly noticeable to the living, is one of the pillars upon which life, and life on land in particular, rests. The body of life is made out of it, powered by it, and even sheltered by it, as the wealth of the sky also acts as a shield

²See Ch. 2 of the first part of this book.

against the powerful rays coming from the depths of the cosmos, which would be noxious to life if they were allowed to strike the earth without impediment. Now that some light has been shed upon the land and the air, now comes the time to recount the arrival of our ancestors on land.

Re-flection: The Land Beneath our Feet and the Air Above Us

Safe inside the motherly womb, the fire of life weaved our flesh and assembled our bones, as our being began in a miniature sea in which we floated freely, without worries, needs, or fears. Our existence started like life itself, in a watery environment, a sea that fed and sheltered us, and only at birth did we feel the weight of our body and the needs associated with the earth and the sky.

When our ancestors stepped out of the ocean to tread on the dry land, our bloodline was birthed anew. They courageously forsook the familiarity and comfort of the sea to venture into the unknown, letting the dry land and the air shape their bodies, adapting it to their new territory, their new home. Like an infant taking its first breath, crying out as it is thrown into the world of men, our forefathers left the cradle of life and discovered the uniqueness of the surface between earth and sky.

Face down on the ground, our arms extended and our palms embracing the realm below as much as we can, we may let our mind be permeated by the realization of our earthly nature, reminded to us by our weight. The earth attracts what shares its nature, the material things venturing close enough to it, and if we do not feel this while immersed in water, it is only because we then are already one with the earth.

Plunging our hands in the mud or the dirt, feeling ourselves penetrating the lower, dark realm, we may be mindful of the fact that there lies the ore from which our body was refined by the furnace of life, and there also lies our ultimate destination, the place where our decaying flesh will serve other beings. The sooty ground, the soil out of which life sprouts, is the mass grave of our ancestors, life returned to death.

To know and experience contact with the essence of the earth, the heart of the dry land upon which we stand, we should nonetheless seek a place virgin of life, a rocky landscape devoid of the corpses of any lifeform. Then may we feel the truth of the earth, its skin harder than an armor, impenetrable by our fingers, and imagine the mountains of molten rocks and metals flowing beneath this crust cooled by the winds.

Rising up and turning our eyes away from the soil to contemplate the realm encompassing all things, we let ourselves be impressed by the stark contrast that the two realms offer to our senses and mind. Waving our arms, we may feel the presence of the air, the invisible cloak enfolding the earth and life, and watching the clouds carried by the winds, the inconspicuous strength of the ether becomes apparent.

The impenetrable nature of the depths of the earth stands against the all-welcoming nature of the lower skies, but behind this veil of clarity and immateriality, hides the heavenly vaults, filled with earthly matter. This crystal-clear air represents the main source of the carbon from which the plants we eat are made, and the woolly clouds hovering above the mountaintops are the spring from which we draw most of our water.

The substance of our body thus comes as much from the soil as from the air, from the earth and the sky, and when the heavenly vaults are wide opened and our faces are showered by the rains and the snow, we may remember that a large part of our bodies is made of this water poured down from the realm above. Refined by the envoys of the sun having robbed the ocean of some of its wealth, it is a gift to life, and it is this perpetual gift that allows us to occupy the face the earth, following rivers and brooks.

Standing on a high point, the almost perfect transparency of the air allows us to delight our eyes with the sight of the horizon, contrary to the murky seas in which we can only perceive what is in our immediate vicinity. Storing the wealth of life, this air also offers us a clear vision of most of the creation, letting itself be continuously pierced by light to show us the earth, the seas, life, and the skies.

By stepping out of the sea, our ancestors brought us to the stage where a great play is unfolded, and we are also actors of the strife between earth and sky, land and air, as part of the tree of life. Pulled toward the ground, to which we are condemned to return at our death, we tend to resist, and we are thus naturally called to elevate ourselves away from death, toward the heights of the heavens. This may be done in the manner of a bird, soaring up in the air to tower over the earth, but we may have other means of elevation, of departing from the earthly to explore the ethereal, the heavenly.

Chapter 2

Life on Land: The Four-legged Creatures

Giving birth to a child can be a long and strenuous event, and likewise, the birth of our ancestors out of the sea and onto the land was lengthy and laborious. They for a long period ventured in the shallows, where the sea meets the land, lifting their head over the surface separating the expanse of water from the air forming the lower skies, and beholding the new world in front of their eyes: not only the celestial luminaries, the clouds, and the small creatures flying through the air but also the land and what is found over it, such as the plants, the animals, and the soil. As their eyes were initially shaped by the sea rather than the sky, it took a while for them to adapt to what was above the surface of the waters, but once those having a special talent to see the features of this new world were selected by life and grew in larger numbers, the range of what they could see above was found to be considerably greater than the one of what they could see below, under water. Benefiting from the almost perfect transparency of the sky, clearer than the most crystalline waters, their horizon was significantly expanded, kindling their appetite for exploration.

The spirit of these ancestors was certainly willing to swiftly explore the newfound territory, but their flesh remained weak. When they briefly ventured on the land, it was at first by tiresomely skipping on the sand or the mud of the shore. Their body was not adapted to such movement, and to a life on land in general.

What drove these creatures to leave the womb of their mother, the sea, was nonetheless certainly not a wanderlust or mere curiosity. As mentioned in a previous chapter,¹ it would seem that the exit from the water would have been caused by a dual movement, by which the sea pushed the creatures out while the land lured them in, with the sea becoming less hospitable to life, probably because of an excess of salinity or an oxygen deficit, and the land becoming an attractive niche, with few predators and an abundance of insects that could be easily preyed upon.

Once the longest and strongest lobed fins were selected, they slowly turned into legs, marking one of the most profound and far-reaching evolutionary changes experienced by our line of ancestors. This transformation was a prerequisite to a conquest of the land by the vertebrate, as motion on land is fundamentally different than motion in water. The forces that dominate the two realms are of a different nature, and their interactions with life are ruled by a different set of rules. The sea is a space where animals can freely navigate across three dimensions. They are carried by the water filling it, with the pressure exerted by it on their body even offering structural support to their flesh. One with the water, the creatures move by simply beating their tail or fins, pushing water away and thereby also initiating the propulsion of their body through the liquid of life. Out of the watery womb, on the other hand, the animals are deprived of such support. The air is not as motherly to life as the sea. It is transparent but because it is largely empty. If the sea was an army made of a compact mass composed of a multitude of water molecules, the celestial ether is an empty field of battle where a few men are unorderly scattered. The lower skies offer their wealth of energy to life, in the form of oxygen, but it will not oppose and cancel the pull of the earth, as the sea does.

As the womb of life, the sea largely rules itself. It benefits from the pull of the earth, which allows it to remain compact and evenly spread across the surface of the earth, and from the gifts of the great luminary ruling the sky, but all that is found within its boundaries remains under the yoke of its army of water molecules. On the surface between earth and sky, there is another balance between the forces of nature. The air in which the lifeforms venturing on the land are plunged is, except for flying creatures,

¹See Ch. 22 of the first part of the present book.

mechanically insignificant. It neither supports nor hinders, only allowing them to peer through its transparency to distinguish what matters to them, the other forces of nature that are more crucial to their survival: earth, water, and life. The central tasks in the life of our ancestors indeed were focused on survival and mating. They needed to find other forms of life to satisfy their hunger or their lust, and to remain close to a source of water to quench their thirst. The exploration and interaction with the surface of the earth were largely only a means to satisfy these desires. They were nonetheless sufficiently enticed by the richness of the land so as to let it transform their bodies, forever affecting their destiny.

When they were in the shallows, our ancestors used their legs as crutches helping them to stay afloat. On land, these limbs must now support the full weight of their body, spread almost evenly across the four of them. A change of geometry therefore occurs, reflecting this need. The body remains parallel to the surface of the earth, thereby lessening the effect of its pull, but parts of the legs are now aligned almost vertically, allowing the creature to rise above the land, minimizing the surface in contact with the dry, which is, when the animal moves, limited to the sole of their feet. These feet are in turn also parallel to the surface, in close contact with it, so that the body can be balanced when some of them are in the air as the animal moves its legs. The earth is indeed a place of immobility and stability, while the air is one of constant fluidity, motion, and instability, and therefore a balance between earth and air must be found by the four-legged creature in order to take advantage of both realms and live on the edge between them. To move efficiently, the feet must leave the surface of the earth and be displaced across the air, but contact with the land is still necessary because of the inescapable effect of the pull of the planet. A compromise, an interplay of land and air, was thus discovered, through selection but also perhaps through a learning process: walking.

Walking is a manner of moving oneself deeply tied to the nature of the land, and the earth under it. Making use of the intricate network of nerves connected to the web of muscle bundles pervading its entire body, the four-legged creature developed a pattern of movements, a choreography where its legs alternate times on the land with times in the air, with the limbs dancing with each other as much as with the upper and lower realms. The loss of



Figure 2.1: *A four-legged creature on land.*

contact with the earth of one foot is tied to the return of another, a precise balance being maintained at all times through the feedback provided by the senses. From its mouth to the tip of its tail, its entire body strives to keep the body as much in the air as possible, escaping the pull of the earth and the friction on the surface of the land by taking refuge in the liberating emptiness of the air. The remarkable suitability and efficiency of this dance to move on land explain why it perdures to this day in most of the descendants of these first four-legged animals. As demonstrated by insects, a greater number of legs would have been possible to walk on land, but a smaller one would not have been practical. To be mobile with a body in the air while minimizing contact with a two-dimensional surface such as the land, a horizontally elongated body would need at least three points of contact upon the land. Like a stool, a three-legged animal would have been possible, but as for many other parts of animals' bodies, the pairing of such parts would prove to be more advantageous. Therefore, the presence of four legs is not only explained by the bilateral symmetry of the creature's ancestors, but also by the advantage that these two pairs of legs provide for the performance of the dance known as walking. Adapting itself from three-dimensional navigation with an almost absolute freedom of movement to a motion

on a two-dimensional plane toward which one is pulled but which nonetheless needs to be kept away to move, this dance represents an incredibly astute response of life to the challenges posed by the pull of the earth and the lack of support of the air.

The lower skies may not support the full weight of the four-legged creatures, as water can, but this nonetheless does not imply that their frailty and the sparse nature of the bits of matter floating in the air cannot uphold anything produced by the animals. The relatively few and far between molecules forming the air indeed represent a gigantic, three-dimensional pool game, composed of an incalculable number of irregularly shaped and minuscule pellets, continuously striking one another according to the play of the forces of nature, of which life is now fully part. Animals already had learned to produce and hear sounds under water, long before they set foot on land, but the usefulness of such a skill proved to be far greater on the latter than in the former. It is precisely the lightness of the air, its lower density, that allows sound to travel greater distances than in water, where it fades away across shorter distances. The transition from water to air demanded an adaptation of the vocal tract. Not impaired by the pressure of the water that would flow inside a widely opened mouth, the animal could now shout with all its might, using its palate, tongue, and jaw as an amplifier setting into motion a prodigious number of the invisible pellets forming the air. As these pellets strike their closest neighbors, the impulse initiated by the animal is propagated in the ether, traveling until the energy imparted to them is exhausted. The vibrations emitted in such a manner by the mouth were then tuned by the creature, and a process marrying selection and learning then began, with sounds producing certain effects on the surrounding forms of life becoming advantageous to their emitter finding themselves preserved and passed on to a greater number of individuals.

Shouts can intimidate a prey, plunging it into a stupor that would make an attack easier. A screeching can also warn the other members of a group, signaling the presence of danger. A purring or murmur can make one's eagerness or readiness to mate known to potential partners. The spectrum of these sounds is wide and each one of them is tried, largely randomly at first. The wooing sounds that lead to reproduction are positively selected, and so do the kind of hissing that would save the life of the members of a

fellowship. Meaning therefore arises once again, out of randomness, through the extraordinary power of the play of affinity and strife, mutation and selection, love and war. Vocal patterns become the signatures marking the belonging to a species, to a race, or a dynasty. They seduce and terrify, attract or repulse, but seldom leave those hearing them indifferent. Inside its head, which is now articulated around the neck to allow it to move independently from the body, bones evolved to act as an antenna receiving and transmitting these sounds to the brain, allowing them to be heard. A great variety of shouts and songs then resound within the animal's world, reflecting what it understands and deciphers of the titanic pool game being played by myriads of players in the ether covering the surface of the earth.

Equipped with its four legs and its now broad array of senses attuned to the life between land and sky, the creature could then undertake a true exploration of the land. Walking on the sandy beaches or the soil of primitive forests, it preyed on other creatures, which were abundant and often defenseless: insects. The land offered the plants easy access to the power of the sun, and these light-workers in turn represented a plentiful and virtually helpless source of food for their predators, leading to an explosion of their population. The highest creatures on the food chain were therefore driven to the land, feasting on this lavish reserve of life. This nonetheless does not imply that the first four-legged creatures would have been spending their life on land. Their mouth and jaw were not yet capable of directly ingesting the prey caught in the air or on the dry earth, and they therefore for a long period needed to return to the sea, using the pressure of the water to push the prey inside their throat so that it could be digested. Their reproduction and birth also remained tied to the sea, as their soft and unprotected eggs would not survive the dryness of bare earth.

Slowly but surely, the four-legged creatures grow more and more adapted to the dry. Those among them who exhibit the greatest capacity to resist the assaults of the winds and the dust thrive while the others perish. Thus did they discover eyelids as a way to protect the delicate membranes forming their corneas. The gills of their ancestors disappeared while their lungs grew larger, reflecting the need for an increased flux of oxygen powering their body, a body that could already be larger than the one of a man. This enlargement of the lungs was paired with a transformation of

the circulatory network and the heart, with the circuit of the red liquid now diverted to flow heavily inside the lungs, which are now the main locus of oxygen collection. By ceasing to breathe through the skin, the animal can begin to seal it, avoiding the need to keep it constantly moist and also preserving its reserve of the liquid of life, which is now a precious resource for the creatures living on the dry land.

The transition from the use of skin-breathing and gills to an exclusive use of the lungs was extremely long, starting from our distant fish ancestors and ending with four-legged land dwellers. From a swim-bladder arising from a series of random mutations of the digestive tract, probably selected by life because it could be used to stay afloat while the body of the fish grew heavier, it slowly became one of the most crucial organs of the body of their descendants. Breathing now certainly is the most conspicuous sign that one of these descendants, including ourselves, is alive. The alternation of inflow and outflow of air through the nose and mouth to the center of the chest is the ticking of the clock of life, marking the pace of our existence, somewhat similar but more conspicuous than the beating of our heart. It marks the tightening of a bond between this branch of life and the lower skies, a price to pay to benefit from the abundance of the celestial storehouse of energy, the vault containing the wealth of the light-workers. Forsaking the sea, these animals had to ally themselves to another force of nature, and the alliance is as demanding as it is rewarding. They will soon entirely depend on the sky for their survival, losing their ability to collect the oxygen dissolved in the water, thereby severely limiting their capacity to return to the depths of the sea for extended periods of time.

The bridges are burned once the four-legged creatures let their body be shaped by the land and the air, forgetting their bond with the sea. Contracting their chest almost every second, letting the air invade the deepest parts of their body, every breath is a blessing and a sign of allegiance to the heavenly realm. Breathing is discontinuous, like the second major sign of life, heartbeats, allowing both of them to offer a contrast and be noticed by others, as meaningful signs. It also is contrasted with feeding or drinking, as both can hardly occur at the same time: one must be interrupted in order for the other to take place, but breathing always has precedence. The creature may indeed survive for days without

water, weeks without food, but if the inflow of air inside the lungs is interrupted for more than a few minutes, at most, the entire machinery of the body would collapse, and the fire of life be extinguished from the animal. Both instinctual and controlled by the creature, breathing then becomes a rather low-key but yet central part of the life of this branch of the middle realm.

By breathing, the four-legged creature nonetheless brings moisture to the air, mingling little bits of water with the heavenly wealth, sacrificing some of its precious reserves as a price to pay for the vast resources offered to life by the sky. The place of the sea in the life of the land animals may have been reduced, as the sky gained prominence, but this does not imply a disappearance of water from their existence, rather only an evolution. They still need the waters of the sea, notably in its form purified and deprived of its salt through the agency of the sun and the winds. The labyrinth of rivers of fresh water running from the highest peaks onto the sea across the entire face of the land constitutes a series of life-lines and paths guiding life inland. The sky therefore not only insufflates the breath of life into the land creatures, it also paves the way for their conquest of the dry land. They breathe the air and drink from the flow of the torrents, rivers, and brooks prepared by the heavenly downpours, carving the face of the earth and bringing bits of it to the heart of the sea. Step by step, generation after generation, the four-legged creatures thus followed these paths etched into the land by the rains, as life as a whole invaded deeper parts of the continents.

By departing from the sea and the coast to invade the land, the four-legged creatures may have loosened their bond with the watery womb that nurtured life until that point in time, but they in a way also extended its dominion. The sea was, is, and will indeed always be part of them. Their body is a watery pouch reproducing many of the characteristics of the place of origin of life. Even to this day, the concentration of substances like calcium in our blood reflects the concentration found in the sea. We carry part of it in ourselves, not only as pure water but also as a complex environment allying water with a variety of substances playing different roles in life. The sea is caught between earth and sky, forming an intermediate layer, sharing the materiality and substance of the first with the transparency and fluidity of the latter, whereas life represents the middle realm that thrived within this watery space

opened up by the sea. Life nonetheless is inextricably linked with water, and if the middle realm can extend its dominion across the face of the dry land, it is because of the work of the celestial forces watering the land and because life keeps this water secured inside the body of living beings, forming countless watery environments mimicking the sea on land. As pouches of water mingled with minerals and organic substances, each land creature represents a miniature sea and an extension of its dominion onto the earth. Standing upon the earth, under the sky, plunged in the heavenly ether with its feet firmly anchored on the soil, they are the middle realm uniting the various forces of nature, lowering the sky to the ground, elevating the earth to the air, and bringing the sea to the dry, with the miraculous fire of life continuously burning, turning death into life, joining what is above with what is below in a wondrous chain reaction uninterrupted since the kindling of the first spark of life, when the earth was young and the beauty of the sky had yet to be contemplated.

Our four-legged ancestors quickly occupied the top of the food chain of the land, submitting under their yoke the insects, the creatures with rigid legs such as centipedes, and the plants. A web of complex relationships and dependencies began to be weaved between different branches of the tree of life, and between these branches and parts of the earth, the waters, and the sky. Insects and plants, in particular, began to evolve together, with surprising partnerships and collaborations between radically different species being selected out of random changes of their library of information or through patterns of behaviors. When a species of insect helped defend a species of plant against predators, which in turn received something such as nourishment or shelter from the plant, both species often were found to be fitter than other species, and thus such associations flourished. A prodigiously intricate web of such relationships thus appeared, also involving our ancestors, who often reaped the benefits of the work of lower forms of life. Their adaptation to their new life on land, however, was only beginning.

Re-flection: Our Life on the Dry Land

Life unhurriedly crept out of the ocean, starting with the humblest of all beings, harvesting sunlight. Increasingly larger specimens of such lifeforms then followed, inviting animals to pursue them, and thus our ancestors stepped out of the water to take refuge or simply conquer the dry land. If we stand here now, it is because our ancestors followed these humble creatures, lured inland by them.

This land we call “dry” would nonetheless not be hospitable to life if it was truly devoid of water, as the fire of life can paradoxically only consume what is soaked with moisture, poured down by the sky. Water therefore preceded life on the dry land, and our kind followed the riverbeds to settle inland, remaining close to sources of freshwater to build the first settlements, drinking from them daily.

The conquest of the land also marked for us the beginning of our reliance upon the celestial storehouse. We ceased to breathe under water and like infants out of the womb, we then filled our lungs with air. Powering the breaking down of sugars and fats into energy usable by the machinery of our body, the fruit of the labor of the diligent light-workers offered us a greater strength than ever before.

Sitting down on the ground and calmly letting this heavenly wealth enter the innermost part of our chest, we may consider the course of the molecular beasts entering our bloodstream from the depths of our lungs. Each blood cell carries this treasured cargo to the cells of our body inhabited by guest lifeforms, the living things harnessing the strength of the beasts to turn nutrients into energetic molecules. If our body moves so efficiently on land, consuming relatively little food, it is because of their labor.

Letting the air in our lungs return to the skies, we may be mindful of the nature of what we release. We have consumed some of the wealth of the light-workers, but in exchange, we offer them what they crave. The wastes of our respiration are indeed what all the light-workers need to live and grow, just like we use theirs and thus are we linked with them, mutually strengthening our branches of life. Like the water poured down from the heavens, the air is a lifeline allowing us to venture on the continents.

Our life on the dry land is thus also a life in the air following one in water, the land itself being secondary. The adaptations of our body to this life, like the transformation of fins into our arms and legs, are indeed made to reduce our contact with the land rather than to tighten our bond with the lower realm. Our limbs keep us in the air, resisting the smothering embrace of the earth enrapturing our flesh, as the upper realm offers us a clear sight of the world and relatively effortless movements in it.

Gently turning our head right and left, looking up and down, we may notice the role played by our neck, and remember that this articulation came to be as a result of the conquest of the land by our ancestors. It allows us to turn our eyes and our attention toward a particular direction, without moving our torso, something rendered useful due to the effort needed to oppose the pull of the earth to set our flesh in motion.

Swallowing a piece of food or taking a sip of water, feeling the muscles of our throat contracting, we may also be mindful of the origin of this movement, emerging as a result of the ascent to the dry. In the womb of life, the seawater indeed pushed food down the throat of our forefathers, but the feebleness and ethereal nature of the atmosphere renders it unable to perform this task.

The winds sweeping the earth are nonetheless far from impotent, and if the land is dry, it is also due to them. What the clouds give, the sun and the winds indeed take away, robbing us of our moisture, threatening life. Watching how the winds carry the heavenly vaults of water around the face of the terrestrial globe, we are invited not to underestimate the strength of the air, which sustains us but may also take our life.

The air in which we live while on the dry land is unseizable but our existence rests heavily on it, as it not only offers us the wealth of the light-workers, freedom of movement, or even the gift of sight, but also carries the voices of the myriad of creatures roaming the earth and flying through the sky. The sounds of the animals and nature as a whole indeed are heard solely because of its agency.

Softly uttering a sound and letting it resound in our ears as it runs through the air around us, we are called to contemplate the role played by the upper realm in this peculiar phenomenon. We can remember the mating calls of the birds perched on the trees or

the shouts of despair of a hungry dog, and notice the importance of the sounds of love and war in the life of all the land-dwellers. The play of love and war is also unfolded in the air, serving as the courier of the animals, and thus while the dry land catches our eyes, we are reminded that we inhabit the air more than the ground.

Chapter 3

Born on the Dry Land: From Eggs to Live-birth

As we contemplate the magnificence of the sea from the shore, where the rumble of the cities can still be heard behind our shoulders, it evokes in us a sense of tranquility and peace. Those among our ancestors who first conquered the land may nonetheless have had an opposite view of this contrast between land and sea. At the time, the land was scarcely populated, and by creatures often far less imposing than them, insects in particular. The shallows are then teeming with animals. Four-legged creatures walk on the muddy floor, while a diverse population of fishes glide through the murky waters in search of their daily sustenance. Rather indiscriminating in their diet, these countless species roam the womb of life in search of weaker beings, feeble cousins on which they could prey. The most fragile, the most defenseless and impotent of them all certainly are the young and the unborn, the roes and eggs that contain the seeds of future life. They are a prey of choice, offering a nutritious meal with relatively few risks of being attacked, at least when they are left unattended. The sea is therefore far from a place inspiring serenity and safety, as the water offers easy access to their young to all sorts of predators. Elevating themselves over the surface of the waters and walking upon the dry land, life nonetheless soon discovered that the dryness and relative inhospitality of the land may provide much-needed safety for the eggs of our ancestors.

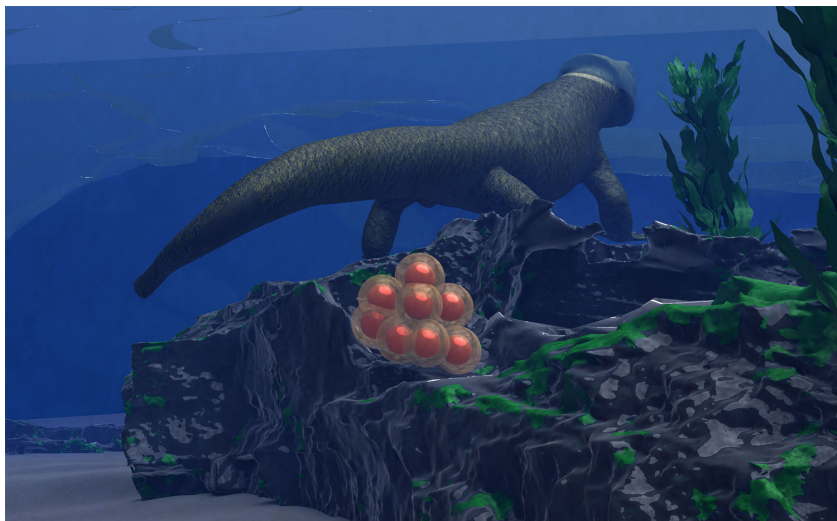


Figure 3.1: *The eggs of a four-legged creature in water.*

The first four-legged land creatures nonetheless first have to discover a new way to perform the ritual of reproduction before they can sever their dependency on the waters for the nurturing of their young. Like the vast majority of fishes, they indeed used the liquid of life as a means of carrying the male's semen to the female's eggs. No contact occurred between the sexes during this ritual, in which the female first laid her eggs on a partially secluded and stable place such as the crevasse of a boulder, before the male sprayed his seeds over them, triggering the merging of their libraries of information and kindling the sparks of new living beings. The nature of this ritual gave the sea a primordial role, as the currents of the water carried the seed to the egg, leaving almost no power of selection to the female, who can hardly prevent the seed of an unworthy male from reaching her eggs. Its performance would be difficult on land, as the fluid filling up the sky like water forms the body of the sea, the air, would not carry the seed, which would then have to be deposited directly over the eggs, and the dryness of the winds would interfere with such an encounter.

The first step that would ultimately lead to the bringing of the reproduction ritual to the dry land occurred in the sea, when a female retained her eggs inside her belly instead of letting them fall down to the sea floor to encounter the seeds that would transform them into new living things. By random chance, a twist of fate,

or as the result of an instinctual impulse to perpetuate his line, a male then encountered this unique female and, sensuously dancing with her in the midst of the sea, he emitted his seeds sufficiently close to the opening inside which the eggs were concealed that his essence successfully reached them, for the first time kindling the sparks of new living things inside the body of the female, who then, at the appointed time, released the fertile eggs into the sea. This marks a turning point in the evolution of our bloodline. The bond between mother and child is only slightly tightened, as the eggs are kept longer inside the body, but the most flagrant transformation is the considerable elevation of the role of females in the evolution of their kind.

The future mother can now choose her mate, the father of her children, giving her the keys to the selection of the fittest males. Females will, from now on, be the gatekeepers of the quality of the library of information passed on to a new generation. They are now in charge of favoring the best and rejecting the others, so that their entire species, and life as a whole, may grow fitter, more capable to conquer the earth and the sky and defend itself from the assaults coming from both the forces of nature and the other branches of life. What this initiates is not a war of the sexes, but rather the establishment of a partnership between them, with males striving against their peers and against nature itself to sow their seeds wherever they find a fertile ground, and females carefully selecting those whose efforts or innate gifts have made them the apex of their kind. This marks the emergence of a new level, a new field for the play of attraction and repulsion, mutation and selection, love and war, one that would hasten the evolution and the rate at which new discoveries would be made by life.

By taking upon itself the task that was before entrusted to the currents of the sea, life therefore takes into its own hands a new part of its destiny. A new step toward independence from the sea is taken, and thanks to the new work of selection performed by future mothers, further changes then swiftly occur. The ritual becomes more and more intimate, leaving an increasingly smaller place to chance for the meeting and commixture of seeds and eggs. A fin of the father evolves into a penis, which penetrates the opening of the female, thereby ensuring that the seeds would not be scattered by the currents. The reproduction ritual therefore becomes a sensual encounter, which may already have been the source of plea-

sure, although its main driving force probably would have been an instinct. This union of the bodies through intercourse already prefigures some long-lasting patterns of gender roles, with the female being a passive receiver of the male essence, nonetheless actively selecting the fittest mate, while the male strives to penetrate females to ensure the perpetuation of his bloodline.

Furthermore, by safeguarding their offspring for a while inside her body, the mother can offer more than protection: she can also give them more nutrients, allowing them to develop faster and longer. She can also choose the most opportune time for their release, waiting to find an environment where they would be more likely to survive. This nonetheless comes at a price. The longer the eggs are kept inside the body, the more space they occupy as they develop, the more they demand from their mother, and therefore in reaction fewer of them are produced. A shift of strategy begins to occur, from the production of a large number of eggs and seeds, which are largely left to fend for themselves and as a result are unlikely to reach adulthood, to the nurturing of a more limited number of children, upon which more effort and energy is invested, increasing their chances of survival. Such a shift may have come as a countermeasure to an increasingly threatening presence of predators.

The new ritual of life-giving discovered in the midst of the waters presents another advantage: it can be performed when plunged in the air enfolding the dry land just as well as in the sea, marking a new step toward the escape of our ancestors from the seas and rivers. Seeking relief from the relentless assaults of fishes and other creatures roaming the seas in search of food, the four-legged creatures therefore not only began to mate on the dry land but also placed their precious eggs in shallow puddles of water, isolated from the body of the sea and its cohorts of ravenous living things. Originating from the ebb of the ocean or the opening of the heavenly vaults, these watery refuges used the earth as a bulwark defending the eggs from the barbarous dwellers of the sea, but they nonetheless also posed new challenges. The soft, translucent eggs indeed at this point are laid bare, exposed to the elements, the dry winds and the fiery rays of the sun, in particular. In all likelihood, a great many of them perished as a result of such exposure, but as always, life does not shy away from a challenge coming from the forces of nature. It once again lets itself be shaped by



Figure 3.2: *The eggs of a four-legged creature on land.*

the heavens and the earth, welcoming its transformation, as it is mercilessly trimmed and pressured so that future generations may enjoy the fruits of the sacrifice of their ancestors and kin. The sun therefore ruthlessly burns those among the eggs that welcome its light, the most translucent. The brutish winds heartlessly desiccate those that are the least able to prevent the theft of their precious life-sustaining moisture, and as this trial by the fire of nature continues for countless generations, exceptional specimens are discovered, eggs that fiercely and proudly resist the onslaught of the celestial forces. Having grown opaque to stop the envoys of the sun from corrupting the life growing inside it, and having developed a rather soft but efficacious shell, the eggs begin to be able to withstand the life on the dry, with only minimal protection, such as a humid hole in the sand.

Once the trials of the heavenly fire and winds have been passed, the eggs of the four-legged creature are remarkably safe. Their shell grows harder together with the passing of time, as those ablest to retain their moisture are continuously selected. They nonetheless do not insulate themselves from the sky completely. Minute openings cover the surface of their shell, allowing exchanges to occur between the growing life and the heavens. These may have considerably lessened the dependency of the eggs on the watery realm, but the creatures inside them still heavily rely on the

heavenly storehouse, the treasure of the light-workers in the form of oxygen, to power their development. The creature also needs to evacuate the waste produced by its own body and its growth, using the earth and the sky as a dung-heap. The sky nonetheless impassively accepts this contribution, letting the new living thing extract as much as it needs from its vaults, which contain far more energy than the sea ever did.

The egg does not only reap the blessings of the heavens. It also profits from the stability of the earth, which offers a stark contrast with the fluidity and unsteadiness of the ocean. The egg is kept in place by the pull of the earth, nonetheless demanding that it be placed in a hole or at least a concave surface. The very contour of these eggs is also progressively shaped by the earth. From a spherical shape that proved to be ideally suited for the waters, the hardened eggs of the land slowly acquired an ovoid shape, slightly elongated, thereby breaking their perfect symmetry. The reason for this transformation is rather simple. The breaking of the symmetry offers the egg more stability. A round egg would tend to roll across any slanted surface, while the ovoid-shaped one would only do so if its largest side is perpendicular to the rolling direction, something less likely to occur and maintain. Many round-shaped eggs probably rolled out of the place where they were laid, perhaps blown by strong winds, and they then encountered rocks that broke their shell and extinguished the fire of life burning within it. The elongated ones were less likely to experience such catastrophic events, and they were therefore favored by life. More in touch and in harmony with the earth, they once again overcame the challenges posed by the earth and the sky, reaffirming the determination of life to build its dominion between them.

The hardened shell of the egg is nonetheless more than a means of insulation from the assaults of the sky or the attacks of insects. It is also a boundary between two environments, between the earth and the sky on the one hand, and what represents a watery environment mimicking the one from which life originates, the sea, on the other. The egg is a watery pouch filled to the brim with nutrients, building blocks of life necessary for the creature's development. Life indeed needs to be plunged in such a fluid in order to grow, as this fluid allows the transport of the bricks of life and the edification of the middle realm to occur. The fluid filling the

egg is a substitute to the nurturing power of the ocean, one made by life itself so that it could cease from relying on the motherly womb of the sea and depart from it, heading toward the dry land, where life could gain greater autonomy, evolving from infancy of life toward adulthood. The time spent inside the egg is a time of preparation, of maturing, which retraces the path taken by the creature's ancestors, who were nurtured by the sea before their descendants were birthed by life onto the dry land. From a single seed-cell plunged inside the liquid of life unto an adult body walking on the soil covering the face of the dry, each new being therefore retraces the entire walk of evolution taken by life itself, from the first spark of life eons ago until the conquest of the land by these walking creatures, recapitulating the (hi)story of life with each generation and the birth of each individual being.

Laying eggs on land, the four-legged creatures therefore break the cycle of regular returns to the sea or fresh-water nesting sites. They still need to follow the paths taken by the streams of rain flowing down from the highest peaks as they run toward the ocean to quench their thirst, but they no longer need water to perform the reproduction ritual and nurture the new life produced by this sacred dance. The leash tying them to the sea, rivers, brooks, or puddles is loosened, as they can now lay their eggs deep inside the continent, in the heart of the dry, without having to leave their unborn children behind in a watery cradle. The dirt will be their crib, and the mud and the rocks will be their bed when they hatch, a hard infancy preparing new beings for a challenging life in a place that demands fortitude and endurance. The location of the eggs remains an anchor-point for the parents, as their daily explorations of the land in search for food is restrained by the need to keep an eye on them, ensuring that they would not fall prey to other animals or be crushed by the rage of the earth or the one of the sky, but this anchor-point can be moved at will, anywhere on the land, allowing the creatures to invade new regions of the dry land, following the steps of lower forms of life already present even in the most inhospitable places found above the surface of the sea.

As a miniature round-shaped sea sitting on the dry land, the egg is a tool wielded by life for independence from the womb of life, the sea, one that allows the four-legged creatures to inhabit some of the innermost parts of the dry land. Its closed, sealed nature allows the retention of moisture inside the shell, but it nonetheless

also implies that the yolk inside it will have to power the entire work of edification of the body growing in it, from the time it is sealed until the day the newborn can crack the shell by itself to be born and thrown onto the dry. This constraint limits the amount of nutrients that can be invested in the growth of the new living being, and thereby also the richness, size, and complexity of its body. Some of the mothers at a certain point began to retain the eggs for a longer period of time after having performed the ritual of reproduction, taking more time to nurture the life growing inside her, pouring more of her precious resources into the liquid envelope in which the children are plunged. As a result of this prolonged motherly care, these children grew more robust than those among their kind that were laid more quickly. They out-competed them in their daily battles for food and for a mate with whom they would perform the same ritual that initiated their own being, and thus was such lengthy retention of the eggs inside the womb favored by life. The longer they stayed united with the flesh of their progenitor, the fitter they grew to an existence in their particular part of the land and their particular era. This movement of prolongation of the sojourn of the unborn inside the maternal matrix continued for a great number of generations, until one day, when this lingering in the entrails of the mother became so lengthy that the young directly emerged from the womb, already sufficiently developed to breathe the heavenly ether and to digest food placed into its mouth. This marks the first live birth.

The seeds of our ancestors will from now on germinate inside the womb of their mother and directly sprout on the earth when the appointed time comes. The benefits of this new form of birth will cause the thriving of the offspring of the first mothers having experienced it, at least in the territories where these benefits are significant. Their egg-laying cousins will remain, up until the present day, as they are sufficiently fit to survive and prosper in many parts of the earth, but the pioneers of live-birth will nonetheless occupy new niches, places where the safeguarding of the unborn inside the belly would help them survive and reproduce in greater numbers. One of the consequences of the retention of the unborn is the strengthening of the bond between mother and children. Their fate is now inextricably linked, with the life of the unborn entirely depending on the survival of its parent, while the life of the mother can be imperiled during the strenuous event of



Figure 3.3: *A pregnant four-legged creature.*

childbirth. The child is now protected from both the onslaught of other forms of life, such as the other members of its kind, and the assaults of the forces of nature. There is no longer a risk of seeing the defenseless eggs devoured while their parents are away, or seeing their shells cracked on the rocky earth. They are at all times sheltered in the innermost parts of their mother. They are safe there, as long as the life of their progenitor is itself not in jeopardy, from the teeth and blows of other creatures, or from hunger, thirst, or disease. The adult child-bearer is nonetheless far more well-equipped to endure the trials of life on the dry land than the unborn, and thus this stronger relationship between mother and child benefits their line as a whole.

The relationship between mother and children is nonetheless far from an equal, symmetrical partnership. The mother sacrifices herself for her progeny, as her children exact a heavy tribute from her, consuming a great amount of resources, for a longer time than their predecessors did. They wear out her body, hindering her movements and thus restraining her capacity to hunt for her sustenance, which is also theirs. This high price is nonetheless gladly paid by the mother, who reaps only one benefit from this offering of her own flesh: the extension of her bloodline, the passing on of her library of information, the inheritance transmitted from the very first spark of life and offered to her as the ritual leading

to her coming to being was performed by her own parents. This compulsion to prolong life, and her own life, through the birth of her offspring is sufficiently strong to make her overlook the price she pays to bring them to the world and accompany them into adulthood and independence.

The weighing down, the exhaustion caused by pregnancy weakens the mother, but this maternal feebleness can trigger a reaction, as life as a whole, and their bloodline in particular, would benefit from a compensation for this imbalance. The new burden placed upon the mother, inside her very flesh, demands that others be alleviated from her, and this role may be assumed by her other half, the other being with which she performed the sacred ritual of life-giving and who also gains from her sacrifice the gift of the transmission of his own library of information, the prolonging of his own life through the one of their children. The assuming of this role by the father will greatly fluctuate according to time and places, but a tendency will nonetheless appear, marking the emergence of more distinct gender roles, together with a greater divergence in the appearance of both sexes, as selection will now also be linked with the performance of these duties tied to one's particular role. Unrestrained in his movements and unburdened by the need to feed new lives growing inside him, the father is therefore in a better position to explore the land, walking long distances in search of prey, or to defend a piece of land from other members of his kind. The bond between fathers and mothers is thereby strengthened, tightened, according to a triangular relationship binding them both to their offspring, paradoxically also linked with the divergence of their appearance. The strife of love and war rages more than ever, uniting families together through love while igniting conflicts with other living things to protect this family. Fathers are selected by life for their strength, their ability to defend and attack, to wage wars against those threatening their mate and his children. Mothers, on the other hand, are selected for their ability to give birth to a healthy progeny, to nurture and care for her children until they reach adulthood.

Uniting their bodies to kindle new sparks of life, while both explore new possibilities offered by the evolution of their body, each in its own direction, mothers and fathers now have different relationships with the forces of nature surrounding them. Mothers tend to be more closely associated with the earth. They are more

static, taking care of the young in a precise location on the dry land, weighed down by pregnancy. Their sense of touch is particularly solicited, as they feel the unborn moving inside them, or touch the newborns, keeping them close to their skin, constantly feeling them, and offering them a sense of security. In contrast with this earthly nature of the mother, the father is more strongly interacting with the sky. His sight plays a more prominent role in his life, as he must explore the land in search of food, water, shelter, or be able to swiftly notice threats to him and his family. His life is one of motion and activity, mirroring the fluidity of the celestial ether. The growing fire of life, the unborn, is more than ever placed on the edge between the upper and lower realms. It is neither in contact with the land, as the eggs were before, nor with the air filling up the sky. Both earthly and heavenly, a perfect synthesis of both, it is before its birth entrusted to neither, remaining fully and only in contact with the middle realm, life as a whole, showing how life grows more self-reliant, tending toward adulthood since it has itself been born out of the womb of the sea and onto the dry land, an adulthood that nonetheless is still far away.

Re-flection: The Children Within Us

The branches of the tree of life are now so wide that they cover most of the face of our planet, after having patiently grown from a single seed braided by nature itself in the ocean, between earth and sky. The lone spark ignited in the waters has now turned into a blaze consuming what is above and below, separating and joining the realms of nature as its emerald and crimson flames rise in the air.

The propagation of this fire covering the earth and occupying the sky is often fascinating, as it offers a singular contrast with the way death, what is not life, is transformed by the flow of time. Our children come to being as the result of the performance of a ritual of love and life-giving, one that occupies our mind and bodies but also takes place inconspicuously, as the merging of two seeds.

Some cells simply cleave themselves, while some creatures release their seeds in the ocean, leaving things to chance, but we are not so, as we have to unite our body with the one of a member of the other sex to give life. We are born to be actors of the play of attraction and repulsion, love and war, through such encounters, and our instincts push us to place this role at the very center of our existence, above anything else.

Picturing such a merging of our flesh with another being, we may feel the call of our instincts, realize that the pleasure and satisfaction we experience is the reward of life for the accomplishment of a duty. Playing the role of either the sword or the sheath, letting our bodies provide a watery environment, the man deposits his seeds mingled with water into the feminine vessel, in a moment of intense ecstasy.

Then only does the ritual of love performed by our seeds begins, unbeknownst and invisible to us, as the multitude of male seeds frantically swim to reach the single egg present in the womb of the woman. A new spark of life is then kindled as this ritual is completed, and it will grow into a blaze inside the mother, while the father has the responsibility of caring for both these living things to prolong his own being, by offering his library of information in inheritance to his children, extending his bloodline.

Placing our hands on the swollen belly of an expecting mother,

we may feel the budding life insider her, and keep in mind that we also were carried in such a manner during the better part of a year. We were protected from the pull of the earth and the assaults of the sky, floating in the watery womb, weaved by life itself while experiencing conditions comparable to those of our remote marine ancestors.

Our bodies continuously strive to find what the sea generously gave our ancestors before they departed from it, and thus, from seed to child, the emerging being is continuously surrounded by the liquid of life. As if reenacting the glorious ascent of our forefathers, out of the ocean and onto the dry land, the wondrous event of our birth is a rite of passage, from the watery womb onto the dry air of the sky.

The miracle of the coming to being of an infant is nonetheless only the culmination of a lengthy endeavor, one that begins long before the ritual of love is performed, when the strife for love is ignited. We indeed not only love the one with which we are prepared to merge our flesh and our seeds, but also mercilessly wage a battle against other members of our sex to attract and seduce our lover.

We may now examine our own behavior and see how the play of love and war affects our interactions with others. As a man, do my compulsion to disperse my seeds leads me to enter into conflicts with other men? Or as a woman, is my selection of lovers the source of enmity or resentment between suitors? Love is fed by war, as war is fed by love, with life being refined and strengthened by this play.

Holding an infant in our arms, feeling its dependency, its helplessness to feed or protect itself, we may see in it the fruit of the play of love and war, the perfect marriage of these opposite forces. We, as men or women, instinctively know what to love and what to hate, what should be fought for or against. This is why this new part of life in our arms is such an exceptional demonstration of the intelligence of life.

Chapter 4

Hardened Creatures: Shields and Spikes

With the bond of our four-legged ancestors with the sea and the network of rivers pervading the land loosened as much as possible, and their anchorage to a nesting place disappearing because of their newfound ability to carry children within their womb until birth, they are more than ever enclined to dwell the most remote, virgin parts of the dry land, for the time being free of competition and predators, leaving them at the top of the pyramid of life in their particular territory. The constant exposure to direct contact with the earth and the sky is nonetheless already a challenge. Walking on the sand, the dust, and the rocks, the skin of the creature's leg is relentlessly abraded. The skin of the most ancient of these land-dwellers would have resembled the one of a frog, soft, permeable, letting moisture and gases flow in and out. Confronted to the harshness of the earth, this delicate coat certainly was rapidly ground down, letting the blood of the animals be spilled on the soil, as a libation watering the land.

Facing such harrowing conditions, the creatures were once again shaped by the earth, like clay in the hands of a potter. As minute changes in the library of information defining their kind and their individuality occurred during each performance of the ritual of life-giving, some of the resulting individuals exhibited a better propensity to resist the abrasion of the earth and the erosion of the winds sweeping their skin. The way they achieved this

was both simple and elegant, and it would prove to be so efficient that it perdured in the body of most of their descendants. Just as the first animals, sea sponges, learned to produce a matrix made with large bundles of long molecules of collagen, thereby providing some structural support while preserving a certain flexibility, the land animals discovered a way of producing a substance also appearing as a long molecular chain, but one that would exhibit a far greater hardness, which would prove to be useful in countering the assaults of the earth and the sky. This substance, named *keratin*,¹ was discovered as the result of random changes in the nature of the skin cells of the creature. Those whose skin contained these hardened filaments were less prone to be hurt in their flesh by the abrasion of the earth, the erosion of the winds, or the teeth of other living things roaming the dry land. They therefore survived in greater numbers, and their specificity was propagated among their kind generation after generation.

The hardening of the skin of the animal is nonetheless not limited to the production of this new cement, this shield of life. The integration of this cement inside the living cells is indeed insufficient, as these cells would still be exposed to the wrath of the elements. The ideal strategy developed by the creatures consists in making use of the lives of skin cells, transforming their nature, so that they would become as useful to the organism after their death as they were during their life. The destiny of these cells, inscribed in their library of information inherited from the seed-cell of the organism, will be to prepare their own death, patiently producing the hardened filaments and weaving them in progressively larger threads and bundles, keeping their product within their wall. When the appointed time has come, the envelope of the cell assumes a different shape, beginning to be flattened. The activity of the cells is dimmed as the cement occupies more and more of its inner space. Soon, its core, its sanctuary containing the library of information itself is flooded with the new cement, as the entire machinery of the cell becomes petrified. The fire of life that burned within this cell is then extinguished, quenched by the flow of cement. The cell became the source of its own death, but far from being an escape from its duty to the whole organism, and

¹The word is derived from the Greek word for “horn”: κέρας. The word designates a class of fibrous molecules rather than a specific one. The word “substance” is here only used for the sake of simplicity.

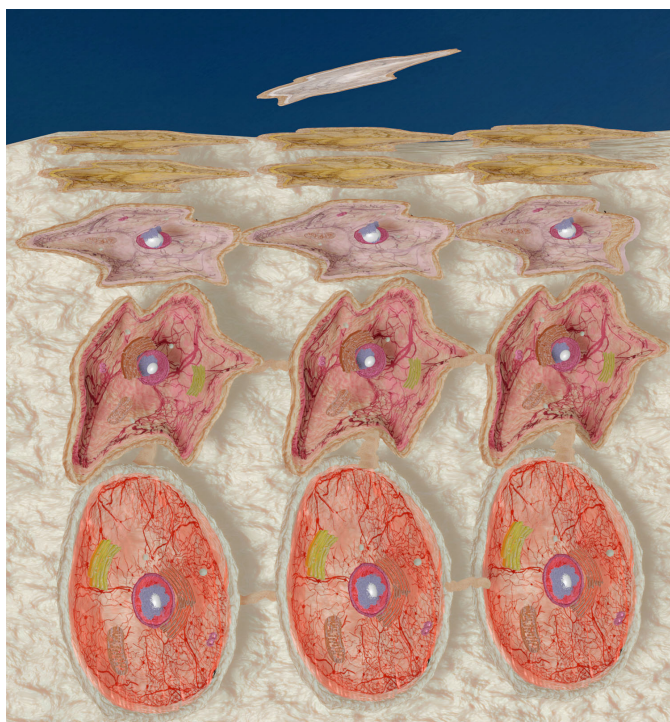


Figure 4.1: *The creation of a hardened skin layer.*

life as a whole, it marks the beginning of what may be its most crucial role, the fulfilling of its destiny.

As the cell becomes like a petrified block of resin, hard and lifeless, it now occupies the outermost layer of the skin. It is the vanguard, the first line of defense of the animal. It serves life by embracing death, making use of the strengths of the non-living. Like all dead things, the petrified body of the cell, embalmed with the unyielding substance that it itself secreted, demands no effort nor energy to be preserved. It can remain in place for an extended period of time without interaction with the rest of the body, staying at its assigned location and performing its duty without command, without food, and without care. It can be sacrificed without remorse and with a negligible impact on the life of the whole of which it is part. Disconnected from the network of nerves that relay information concerning damage or pressure, the dead skin cells represent an insulating layer between the living and the dead, the life that burns within the body and the realm of death that is found beyond the skin: the earth, the sea, the air, and the sky. When they have served their time, and replacements have already been placed under them, they are shed like autumn leaves, falling down to be reclaimed by the earth, as a new generation of petrified corpses is placed on the front-line of the body.

What is built all around the body is a shield. It is life turning death into life, as it integrates earthly matter into the chain reaction, the fire of life, so that it can then be turned back to death, in a precisely determined way, as countless minuscule plates of armor that would protect the delicate flesh found under them from the onslaught of the elements. Like the bones and the scales first discovered by the marine ancestors of these land dwellers, these plates of armor are the result of a subtle balance between the need for rigidity and hardness and the necessity for the skin to remain flexible and not hinder the movements of the animal. This shield is nonetheless not only something that prevents the intrusion of foreign matter into the body. It is also a sealant, precluding the escape of the precious liquid of life, water, which is now often in limited supply on the dry land. As the envoys of the sun mercilessly pound on the skin of the creature during the daytime, attempting to penetrate its flesh with its fiery arrows and bring its wealth of water into the air as a tribute to the sky, all that they encounter is death, the petrified corpses that form the first line of defense of the

body. Already devoid of water and insensitive to the assaults of the fiery, celestial orb, the attack is therefore fruitless. Confronted with the impenetrable shield, they leave empty-handed, either absorbed by the shield itself or repulsed outward, leaving the watery vaults of life intact.

Life thus grows wiser. It not only can edify itself by burning death to feed the fire of life but also begins to take control over the death of its parts, determining at birth the role played by some cells after their death. Life now masters death as much as itself, using it to fight against itself, death used to resist death, showing once more the incredible power of discovery and innovation of the play of mutation and selection, love and war. Life is now more than ever entrenched in the realm of death, the dry land, but as it overcomes every challenge posed by the dry, it also begins to dominate it. Fearless and unrelenting, life advances inward, deeper into the continents, as it blurs the lines between life and death, the middle realm and the ones above and below, and uses the strengths and the attacks of these realms against their source. The earth and the sky are nonetheless not enemies of life, and their opposition and attacks may be seen as mere guidance, harsh trials by parents meant to push their offspring toward adulthood, toward independence and greater resilience.

The play of love and war continued after this discovery of the power of death for the protection of life, and then began a long series of trials to determine the ideal design for this new suit of armor. The balance between hardness and flexibility is indeed one that must be determined and constantly reevaluated for every part of the surface of the body. The thickness of the layer of dead cells, petrified in *keratin*, will be correlated to the severity of the assaults by the realm of death upon life. Callous feet, with a substantial layer of hardened dead cells, allow the animals endowed with them to run over the face of the earth without regard for the coarseness of the soil, the presence of the spines of plants that could pierce through the sole of their feet or the blazing heat of the rocks bathed in the light of the summer sun. They can race through the obstacles placed on their path and at lightning speed fetch the prey they chase, whereas their soft-skinned peers are left behind, tending to the wounds on their feet, their belly empty. More skilled in the art of war, against nature and other living things, the creatures with a hardened skin therefore have better chances of finding a mate,

performing the ritual of love and spreading their gift among a new generation, thereby fortifying their kind and the middle realm as a whole. Likewise, every inch of the skin is subjected to this trial, determining the ideal hardness and thickness of the shield, according to the pressure exerted by the earth, the sky, and life itself, which are continuously reevaluated to reflect the fluctuating nature of its surroundings. Made to resist the abrasion of the earth, the erosion of the winds, and the teeth of other living things, the hardened skin allows the creature to endure environments that would have decimated their ancestors.

The unabated exploration of the possibilities offered to life nonetheless continues. Each new discovery opens a doorway toward further breakthroughs, with life gaining strength in its strife against the earth and the sky with each step taken forward. New experiments are thus made, as the kindling of each new fire of life that comes as the fruit of the performance of the ritual of love brings new changes to the libraries of information. One of them pushed the process of hardening to an extreme, through the production of a particularly dense and compact matrix of cells petrified in *keratin*, one in which these cells would merge into a single block, without a natural shedding of individual cells, which would fall down when a replacement would be ready underneath them. Placed at the tip of the five fingers of each one of their four limbs, these protuberances of hard, dead matter coming out of life would continuously grow, never abandoned by the body. They will remain part of the creature until they are worn down by a violent abrasion or broken by something even harder than them. This marks the appearance of claws, which are only an extension of the process of hardening of the skin that followed the conquest of the land. They could have appeared on any part of their body, but for now, only on the tip of their fingers did this discovery provide an edge for survival on the dry.

Claws are rudimentary protuberances, made of dead, hardened matter, but they are incredibly versatile, providing invaluable assistance in the performance of a considerable number of tasks. They are tools attached to the body. They are hooks allowing the creature endowed with them to hold on to a slanted surface, permitting it to resist the pull of the earth, and even to climb the trees, the cliffs, and mountains, elevating itself closer to the sky. This opens up new territories for the animal. No longer grounded



Figure 4.2: *Hardened skin and claws.*

to the planar surface of the earth, it can conquer the canopy of the forests, if its size is sufficiently modest, and climb the steepest slopes to reach the highest peaks. Claws also offer a grip on the soil when the creature runs over the earth, increasing its stability, its mastery over its movements, as well as its speed, thereby improving its chances of successfully catching prey or evading threats. The essence of what they offer reflects their nature, as earthly matter, as they give the animal the power of the earth. They bring the creature closer to it, not only because they are themselves made of dead, earthly matter, but foremost because they allow the animal to cling on to it, inserting them into the soil, penetrating the heart of the land with its fingers once the claws have opened up a way. Puncturing the face of the earth, the claws allow a deeper intimacy between the living being and the lower realm, but it also marks the assertion of a gain of power, an attempt to show that life intends to claim new parts of the earth as its dominion.

Claws are indeed more than a tool for stability and anchorage. The four-legged creature can and will now use these appendices to carve the face of the earth, transforming its natural shape to appropriate it. Stabbing, scratching, or scraping with its front limbs, the animal can now dig deep into the soil, changing parts of the landscape with its own limbs, according to its needs and whims, rather than simply inhabiting it. If under the assaults of the winds or the sun, it can now take refuge into the earth by digging out a den, further increasing its bond with the lower realm as it attempts to resist the aggression of the upper one. The creature therefore enjoys greater freedom and greater independence from the forces of nature. It continues to grow toward adulthood, taking its survival and the extension of its bloodline into its own hands, rather than simply relying on the benevolence of its parents, the earth and the sky.

The sharp, hardened tips of the fingers are nonetheless not mere tools used to assert a dominion of the earth or to bring life closer to it. They are also weapons, used by living things to protect their own life and the one of those with whom they enjoy a particular affinity, or to extinguish the fire of life burning within the flesh of their enemies and prey. The serrated blades can lacerate the skin of other creatures, thereby encouraging the improvement of its shielding. They can puncture, tear, or slash flesh. They are instruments made of death, non-living matter, that also bring

the living back to death, preparing them to be devoured to feed the fire of life burning within other creatures, thereby proclaiming their loss in the great game of affinity and strife, love and war, with their blood spilled onto the soil as a libation, but thereby also playing their role in the improvement, the refining of life as the whole, with the unfit sacrificed and devoured so that the fittest could benefit from the resource stored within their flesh, their wealth of nutrients. This shows the remarkable nature of the constant play of interactions between life and death, with death, in the form of the claws, shaped and used by life to extinguish other forms of life so as to avoid death, the extinction of the fire of their life, and thereby foster the refining and growth of life as a whole. More intertwined than ever, life and death, the living and the dead, are constantly exchanging with one another, in a perpetual flow that sees life edified from death and then inexorably returning to it, in a cycle uninterrupted since the kindling of the very first spark.

Re-flection: Death Covering Us

The cradle of life, the expanse of translucent liquid covering most of the earth, is pleasant to our senses. It offers a savant blend of firmness and softness, support and fluidity, allowing smooth motions. Our life on the dry land offers us a stark contrast in comparison with this idyllic existence in the sea, as contact of our naked body with the craggy earth is a source of lacerations and abrasion of our skin, while prolonged exposure to the heavenly forces leads to its parching or freezing, erosion or cracking.

When our ancestors were born out of the liquid womb of life and onto the dry land above its surface, they then discovered the preciousness of water, as it became rare and they had to strive to retain theirs. Facing violent gusts of dry wind as we contemplate the open country, we feel the desiccation of our skin. We witness how the skies rob us of our moisture, as our thirst invites us to compensate for this loss. This aggression nonetheless only exceptionally will threaten the integrity of our flesh and our existence.

Life has patiently toiled to perfect our nature, and our skin has now been tailored to face the land and the air. We are from head to toe coated with a thin layer of dead cells serving as a rampart protecting our life, with life shrewdly sacrificing parts of itself to counter the attacks of the realms of death, earth and sky. Touching our skin, the surface of both what touches and is touched is as dead as the rocks beneath us, and as we feel the nerves under this shield of life triggered by our touch, we may consider its nature.

We wear a suit of armor of life, made with death, from our birth until the day we embrace our extinction, and as we observe our naked body, we may notice how life has adjusted its thickness to our needs. The parts of us seldom entering into direct contact with the land or the air are rosy and soft, while those regularly abraded by the earth are more callous, equipped with a heavier plate of armor. Beholding our fingers, one may immediately see if we earn our sustenance using our hands or not, as the workers of the earth bear the indelible mark of their toil, a skin reinforced following frequent aggression.

Mastering death to serve the interests of the middle realm, life gave us this finely refined enclosure. Made of a multitude of infinitely small flakes, the petrified remains of the living cells

below them, they represent a perfect compromise between the need for armor to protect the one wearing it, and the need for enough flexibility not to hinder the movements of the body, as it hunts or flees. Feeling the bending and stretching of our skin as we move, pinching it with our fingers, we may reflect on this inconspicuous presence of death coating the entirety of our flesh.

Life nonetheless gave our ancestors more than a suit of armor to defend their life. It also gave weapons to attack. Beholding the back of our hands, we may see the vestiges of one of the main weapons of our forefathers. The nails on our hands and feet are also made of dead, hardened cells, but compacted in large piles, and even though they are now only seldom used as innate tools to scratch or tear little things, they were once dreadful claws that could profoundly slash flesh and pierce the thickest armors of life.

Our nails are the remains of archaic instruments of death, themselves made of dead matter, continuously growing on us, and as we trim them with tools of steel, we may notice the absence of pain as they are severed from us. They are the product of our body but they are no longer part of life, only senseless bits of earth. Seeing how they serve and protect our flesh from harm, and are the fruit of the work of our body, we may take a little time to ponder the question of where our being begins and where it ends?

The dead cells forming the outer part of our skin and our nails were destined to serve this purpose, as their role was inscribed in their library of information, fated to serve life with their death. Unconsciously and selflessly, they sacrifice themselves to serve the whole of the body, the whole of life, and by their example, they invite us to wonder whether we may also serve life through or after our death.

Chapter 5

Fighting Ice and Fire: Warm Blood and Sweat

As the heavenly wheels continue to turn, with the alternation of the days and the night, the summers and winters marking the pace of their revolutions, the face of the earth reflects the celestial movements. When the radiance of the fiery orb floods the land without restraint, life on land is threatened by droughts and fire, striving to find relief in the entrails of the earth, in the shades of the mountains or the depths of caves. Conversely, when the splendor of the sun cannot reach the living, they must wage a similar battle against the coldness of the earth and the winds, against the wetness of the rains and the dew, which steals the precious heat out of their flesh, threatening to quench the fire of life burning beneath their skin. The living things dwelling on the face of the earth are far more subjected to the changing and unpredictable nature of the sky than their marine cousins. Because of its sheer mass, the sea remains almost impassive to the swift variations of the heavenly forces. The ballet of the night and the days, the winters and summers leaves the ocean almost intact, and only long-lasting tendencies profoundly affect the dwellers of the deep. It is not so with the creatures of the dry land, as their flesh is constantly under pressure, kneaded by the sun and the winds like a piece of dough, forced to endure rapid changes of their habitat, unbearable heat or extreme cold, with both sometimes experienced during a single day. Land dwellers have their feet on the ground, the earth, but they

are plunged in the air, the ether filling up the lower skies. They are therefore pushed to resist the whims of the heavens, which take their toll on each generation, winnowing the weak, those unable to withstand the ferocious but loving guidance of the celestial forces, forces that invite life as a whole to stand up against them.

The battle raging on the ground is nonetheless not limited to the one waged between life and the celestial forces. Within the middle realm itself, a ferocious struggle is now taking place, contributing to the trimming of the tree of life. Individuals fight against their peers, and members of the same kind are at war against other branches of the tree. The tree itself continues to grow in height and in width, covering most parts of the earth under the shadow of its leaves, with each branch more and more separated from the others with each revolution of the earth around the sun. Our direct ancestors then become separated from branches that are familiar to us, such as the birds, which will continue to lay eggs, the crocodiles, or another, which is known to us only through the petrified remains engulfed by the earth, as this branch was abruptly cut off the tree of life at a later point: the dinosaurs. A series of hierarchies emerge, defining the relationships between the branches, such as the demarcation between predator and prey, but there is no objective superiority of one compared to another, as each has its place in the whole of life. Without the simplest, the humblest forms of life, the more complex, sophisticated ones would not be able to survive on their own. Branches evolve at a faster pace when they are subjected to a pressure coming from the earth, the sky, or life itself, and on the contrary, when they are sufficiently fit for the part of the earth that they occupy, they mostly remain as they are. This explains why relatively primitive forms of life have flourished from the earliest time until the present day, with lone cells cohabiting harmoniously with sponges, jellyfishes, worms, fish, or lizards, with an evolution that does not demand the superseding of the oldest forms of life. Each one of them finds its niche, while life as a whole continues its work of exploration and evolution.

The various species populating the dry land are thus treated differently by the earth and the sky, according to the time of their existence and the place that they occupy. Some appear to be cherished by them, offering them all that they need to live and flourish, but this apparent kindness of nature almost ineluctably plunges them into a state of evolutionary lethargy. Without ex-

perienicing the wrath of the earth and the sky, these branches of life are condemned to remain as they are. Without the hands of nature trimming these branches, nurturing the exceptional individuals while annihilating the unfit, they stagnate, only serving the whole by the support they provide for those who endure the harsh guidance of the earth and the sky. The ones experiencing hardships are therefore the most blessed parts of life, while those enjoying relief and peace can be seen as the ones that are neglected, considered less significant by nature itself. Our remote ancestors will once more be the recipients of such a blessing, those forced to endure such a trial, the trial of fire and ice, which will mark a new turning point in the path taken by our bloodline, the walk of our kind toward maturity and adulthood.

The hardening of the skin that came with the life on the dry land allows the four-legged creatures to retain the moisture of their flesh, not letting it be stolen by the winds and the sun's rays. They discovered ways to survive and even thrive while exposed to the brilliance of the star illuminating the earth. Now, however, comes a different time, one when the difficulty is not to endure heat and desiccation, but rather one during which it is the veiling of the sun, the absence of its radiance, that poses a threat to life. The exact cause is uncertain, and its determination is only of secondary importance. The entire globe may have been enshrouded with cold winds, snow, and ice, following a dimming of the sun's fire, a random cascade of events affecting the earth and the ether enfolding it. It may perhaps even have been caused by the fact that these creatures would have lived under a thick canopy, which would have harvested most of the gifts of the sun before the living things under it could receive the blessing of their warmth, which until then maintained their body at a temperature sufficient for the fire of life to continue burning within their entrails. No matter the cause, the effect is clear: our forefathers were subjected to an intense pressure, with many individuals struggling to keep the fire of their life from being extinguished by greatly fluctuating temperatures, excessive heat but probably mainly an unbearable cold. Unbearable nonetheless does not necessarily mean extreme. As their offspring now developed within the motherly womb rather than in eggs, and as heat can greatly influence the growth and the viability of the seed of these new living things, the mothers who failed to preserve their body heat or get rid of it when needed would lose their chil-

dren or give birth to some whose development would have been impaired. The individuals who were the most efficient at keeping their body temperature constant while the sky changed from ice to fire, or from blazing to freezing, prospered while others perished.

In order to gain a certain level of control over the temperature of their body, our ancestors had to make two discoveries: how to produce heat when cold reigns over the earth, and how to evacuate such heat when cold is needed. Heat is something that is directly experienced by us through our senses, but the understanding of its nature was nonetheless concealed to man until recent times. It represents a form of energy imparted to matter, causing the particle forming it to continuously move, colliding with one another and transmitting part of this energy, this motion, to all the earthly things with which they enter into contact. Such a motion, like the currents of the sea, is necessary for the reactions linked with the burning of the fire of life to occur. Without heat, the body would be frozen, without reaction, without motion, and without life. If, however, this continuous motion of each particle of the body grows without restraints, if they for example enter into contact with a fiery substance that would communicate the energy of its inner rage to the living thing, the motion of these particles becomes so chaotic and violent so as to tear apart the bonds forming the various, painstakingly assembled complex substances of the body, turning them into simpler compounds, or simply lacerating the envelopes of the flesh, smashing the machinery of life. A balance must therefore at all times be kept in order for the fire of life to continue burning.

Since its inception, life has always been constrained by its need to remain within a certain range of temperature. In the sea, this was relatively easy, as the temperature of the ocean varies slowly and predictably, allowing the creatures to find a place where they would not be threatened by the raging activity of fire or the deadly quietude of ice. Plunged in the heavenly ether, our terrestrial ancestors are facing a more volatile and extreme environment, but fortunately, they possessed within themselves the secret of their own evolution. They already possess vaults of fire, concealed under their skin, all around their body, a wealth of heat that only demands a key in order to be released. Heat-producing sparks are already continuously flashing in every single cell of the creature, fading away as quickly as they appear as their energy is diffused in-



Figure 5.1: *From cold blood to warm blood.*

side and outside the body. These faint sparks are only a byproduct of the myriad of reactions forming the machinery of life, but they show that life is able to generate heat, in particular when the organism unlocks the energy stored in the form of nutrients to power itself. As seen in a previous chapter,¹ when a chemical key enters into contact with a nutrient, corresponding to a precise pattern of attraction and repulsion, energy stored in the form of chemical bonds is released, allowing new bonds to be formed in other substances, or movements to occur. This unleashing nonetheless also releases energy in the form of heat, chaotic motion imparted to molecules and diffused across the matter with which they enter into contact. Sugars and fats present in the body can thus become sources of heat, and all that is needed in order for this to occur is an incentive, a pressure coming from the earth and the sky, rewarding those able to increase this burning of nutrients, to turn the faint sparks into a living furnace.

The result of the pressure exerted by the earth and the sky upon our ancestors is the emergence of a population increasingly

¹See Ch. 6 and 7 of the first part of the present book.

capable of triggering the release of heat through the “burning” of nutrients, a heat that then becomes an end in itself rather than a mere incidental byproduct of the work of the inner machinery of the creature. Diffused all across the body, this heat can now make a difference between life and death, when the sun is veiled and frigid tempests sweep the dry land, stripping it of its warmth to carry it to the firmament. This relatively modest change in the body of the creature would nonetheless have profound repercussions on the relationship that its kind will now have with the celestial forces. Our ancestors indeed no longer need to be exposed to the face of the brilliant star passing daily through the heavenly vault to be blessed with warmth. Even when walking through deep valleys, in the shade of sky-high trees whose leaves would welcome and enslave every single envoy of the sun, they will not be threatened by the frigidity of the soil, as they now are endowed with the power to kindle the fire of life burning within their skin. All they need is food, and they can then survive even when the sun veils its face and denies its brilliance. Their own bodies will be miniature suns, radiating heat but no light, dark stars that will burn in the shadows, like candles scattered on the earth during the night. The four-legged creatures have learned their lesson from the skies, and they can now stand up against them. The heavens have taught them a way to wean themselves from their dependency on the celestial radiance, which impaired their conquest of the land.

The creatures can now impassively withstand the daily retreat of the fiery orb beyond the horizon, the uproar of the winds, the rains, and the snow, within certain limits and only if they can find a sufficient quantity of nutrients to feed the fire burning under their skin, like chunks of coal thrown into a furnace. Life may find itself emboldened by this new discovery, which would appear to elevate its status within nature, its importance as a participant of the strife between its forces. Reacting to the celestial guidance, the pressure of the heavenly hands, it indeed unveiled a means to loosen the bond tying it to the sun. Life should nonetheless not forget that the realm above, and the blazing star around which the earth revolves in particular, remains the source powering its machinery, feeding its fire and preventing its extinction, even if the link between the four-legged creatures and the sun has become obfuscated by the growing intricacy and complexity of the tree of life. The nutrients that are used to produce heat and raise the

temperature of their body are indeed themselves only receptacles of the celestial brilliance. They are the fruit of the work of the light-workers, the producers, the humble forms of life that encapsulate the radiance of the star into chemical bonds, forming a mosaic of substances containing energy that can later be released. The fruits of their work sustain various animals feeding on them, on plants, and these animals, after having turned these basic nutrients into muscles, fats, and flesh, themselves feed higher forms of life, such as our four-legged ancestors. The sun therefore remains the source of energy setting life in motion, even when life appears to be able to produce its own heat rather than receive it directly from the skies.

The warm-blooded creatures have now gained more independence from the flaming forces of nature that offer their warmth to life, mainly the star above, but sometimes also the rivers of molten magma flowing in the deepest parts of the earth, and their manifestations: the hot springs and volcanoes, which probably played a crucial role in the emergence of life, and which in some part of the earth continue to sustain it. This greater autonomy nonetheless comes at a price. The continuous burning of nutrients, at a considerably increased rate compared to their cold-blooded ancestors, implies a more voluminous supply of food. The need for such an important consumption of living things, plants or animals, may be one of the reasons explaining why the size of our ancestors would then be considerably reduced, from almost human-sized cold-blooded creatures to warm-blooded ones whose size was often more similar to the one of our common rodents. Those consuming fewer resources were favored by life, as they could more easily be satiated from the land, while the larger ones starved or retreated to areas where food would be the most abundant and the sky more clement. The elongated body of the first land dwellers gave place to more compact ones, with thinner tails and legs, minimizing the loss of heat to the soil and the air.

The warm-blooded creatures are nonetheless not only threatened by the denial of the sun's gift. They can just as well be brought on the brink of death by excessive exposure to the celestial radiance as by its disappearance. The torrid gusts of the desert or the steamy air of a tropical forest during the summer can indeed quench the fire of life as swiftly as ice and snow. Responding to the threat signaled by its senses, the animal may develop strategies to

avoid such threats, such as the digging of a den in the depths of the soil, to find solace and coolness from the blazing rage of the sky in the motherly womb of the earth, but the pressure exerted by the sky once again will induce a selection that would lead to new discoveries. A large number of these warm-blooded creatures perished from excessive heat, or perhaps simply failed to give birth to healthy offspring, before a special individual emerged, one who was endowed with a unique ability that would greatly reduce the threat posed by an overbearing presence of the sun. The skin of the animal is now both soft and flexible, but it is also coated with a very thin layer of slightly hardened cells. This balances the needs for protection from abrasion, convection of heat, and free movements. This balance also allows something new to occur: when its body is overheated, it may secrete water out of its skin, sacrificing this precious resource as an offering to appease the rage of the skies, as the winds take away both this water and the heat it carries, cooling the skin and therefore also the entire body. Warm blood is thus paired with sweat, both representing responses of life to the dual threat coming from the skies: the veiling of the sun and the denial of its warmth on the one hand, and an excessive exposure to the fullness of its radiance that brings on unbearable heat on the other.

Sweating allows the warm-blooded creatures to remain active, even when they are struck by the sun for extended periods of time. They no longer need to seek refuge in the shades or the depths of the earth when their flesh becomes too hot. They can hunt or forage, run or jump, with the sweat running over their skin transmitting the coolness of the breezes to it, taking away the fever that took possession of their body. As long as water is abundant, the animal can then simply quench its thirst to replenish its depleted supply and continue to toil and sweat, offering it a considerable advantage over its cold-blooded cousins.

The threat of heat may nevertheless not only come from the outside but also from within. The elevation of the temperature of the body indeed helps the development of new living things within the motherly womb, and countless other functions of the body, but in the body of their partner it also posed a challenge, as such temperature tends to be noxious to the seeds produced by the males, which are indispensable for the performance of the ritual of love and life. Once more, a selection pressure was therefore

applied on life, but here one coming from life itself, and affecting only the males. Those among their population who succeeded in keeping their seed cool reproduced in larger numbers than others, inviting the discovery of new strategies, among which is the one that remains in use in our own kind, that is, the emergence of external testicles. This evolution is very peculiar, as it represents a radical change of a very old and deeply anchored principle of life, the fact that before this the seeds were mostly kept in the deepest, the safest, or the most inaccessible parts of the body, as the life of the blood-line entirely rests on them and their protection is paramount. Following the elevation of the temperature of the body, these are nonetheless now exposed, and can more easily fall prey to injury or attacks. This strategy nonetheless succeeded and was found by life to be an ideal compromise between safety against injury and overheating, and this threat may perhaps even have induced a further selection, favoring more careful, reactive animals, those able to avoid injuries and attacks.

The repercussions of the ability of the warm-blooded creatures to control their own temperature on their kind are profound and wide. It not only led to a transformation of their bodies but also deeply influenced their way of life. Their cold-blooded ancestors were forced to prostrate themselves in front of the sun after the dawn, performing a daily ritual by which the frigidity of the night, which plunged their muscles in a state of lethargy, would be chased away by the welcoming of the envoys of the sun, warming their skin and fanning the fire of life within them. Only after the completion of these lauds officiated by the celestial blaze would the activities of their day begin, with their body reinvigorated by the heavenly warmth. Their daily routine would therefore be performed under the auspices of the sun, and their toil would cease when the star would retreat beyond the horizon, as the chilling breeze of the evening would mark the time for them to return to their den, escaping the darkness and coldness of the night by taking refuge in sleep. The warm-blooded creatures, on the other hand, have freed themselves from the need to perform this ritual of the dawn. They are not bound to the sun as their cousins are, and they thus are granted a new territory, which is virtually virgin of predators, one that is not defined as a mere expanse in space but also one in time.

Generally smaller in stature than most of its cold-blooded

cousins of the time, the warm-blooded creature is then meek and would easily fall prey to some of them if it were to be confronted with them. It nonetheless learned to make use of its unique advantage, and slowly began to concentrate its activity during the dark hours, when only the faint glow of the moon and the milky way shines upon the dry land and most of the larger creatures are sound asleep in their hideout. The night becomes its dominion, as few others are able to run, forage, and hunt without the benevolent presence of the sun over their head, which gives them the warmth necessary for their internal machinery to function. It lives while predators and competitors sleep, and it sleeps while they are awake, thereby significantly reducing the risks that its life would find itself threatened. Its eyes will slowly adapt themselves to the faintness of the nocturnal glow of the sky, allowing it to see others while remaining unseen. Seldom facing the blazing radiance of the sun, its skin will progressively lose some of its ability to resist the piercing power of some of its rays, but this will not impede the life of its descendants. Its capacity to withstand the volatility of the skies will soon allow them to reign supreme over life, not only during the night but also when the land is showered with light.

Re-flection: The Fire Within Us

Life is a wondrous chain-reaction, a fire consuming the earth as it elevates its flames towards the skies, one that burns between the blazing orb in the sky and the rivers of magma flowing under our feet. The middle realm is caught between these two furnaces of nature, and they set bits of earth in motion, allowing the reactions causing life to grow to occur, with cells unceasingly expanding and dividing themselves.

The reactions forming the machinery of our body can only take place within a narrow range of temperature, and the crossing of this range will often imply irreversible damage and the quenching of the fire of life. An infinitely small chaotic agitation of all the particles of our flesh is the oil of our machinery, stimulating the formation or rupture of bonds between them, according to a patiently discovered balance, and thus can the play of attraction and repulsion upon which life is based be unfolded within us.

Carefully placing our hands close to glowing embers or putting a chunk of ice on our naked torso, we may feel the balance of our body being disturbed, as it reacts to this presence threatening our life. The flame brings an excessive commotion to our skin, breaching the walls of cells and tearing their servants apart, while the iciness leads to the solidification of the machinery and the expansion of the water it contains.

Successively plunging our entire body in steaming and frigid waters, letting them imprint our senses, we may reflect on the nature of the two poles between which the fire of our life is confined. The reactions of our body may also be observed, to see how it strives to keep our machinery in balance, as we sweat large drops from our front-head to let our heat be carried away by the air and the winds, or frantically shiver as we lose control of our muscles, in a desperate attempt to keep the fire of life going.

Having contemplated the unconscious wisdom of our body, which knows how to react to an imbalance of the chaos within it, the progress of life may be appreciated, as we are now a source of radiating heat between earth and sky. We are dark suns burning on the dry land, heating the cold air of the night when our star sleeps beyond the horizon, as creatures not endowed with such a power seek to take refuge near us, gravitating around our fire.

The meals we take each day, prepared with the leaves, the fruits, or the flesh of other living things, they are burned within our cells, increasing the commotion between all the parts of our body. Ultimately, this energy of life burned within us is nonetheless only a gift of the sun itself, its radiance encapsulated as bonds between atoms, ingested by us, and then released by our machinery. By day or by night, during the summer or winter, the source of the fire of life thus remains the brilliant star above us.

Like a string of firecrackers, the sun's brilliance stored within nutrients is unceasingly released within us, while the substance of the ocean, drunk by us once it has been purified in the sky, flows out of our skin. Our body wields the strength of the sun and water like a two-edged sword defending life and keeping it in balance, using all its might to repel the assaults of the earth, other parts of life, or those of the heavens.

Using the strength of the yellow star, women are now able to sustain a growing life inside their womb, insulating their child from the coldness of the dark landscape of the polar regions during the winter, or the suffocating heat of the equatorial lands, bathed in fire and swept by torrid winds. Protected by its mother, using water and fire, the child can safely see its own body weaved by life.

Life nonetheless also shaped the flesh of the future fathers, protecting their seed from harm, but in their case, the greatest threat to the integrity of their essence was the fire burning within them. What is, from the point of view of the tree of life as a whole, the most precious part of a man's body, the one ensuring that he will father new beings, has thus been insulated from the overbearing heat of the belly. Contrary to a woman's, the seeds of a man need closer proximity with the winds, keeping them cool.

Men and women thus wield differently the power of the sun and the one of the winds, according to their needs. Each one of us continuously consumes the strength of the star above, harnessed and stored by others, also letting the waters of the ocean flow out of our skin to let our surplus of heat be carried to the clouds. Thus we preserve the balance of our being, carrying the flaming torch of life through a landscape of death.

Chapter 6

Coats of Life: Hair and Fur

The emergence of claws was a successful experiment by life. The outgrowths coming out of the skin of our ancestors proved to be useful in their unceasing struggle for survival and the perpetuation of their bloodline. The mechanism that gave rise to these outgrowths, using specialized cells sacrificing themselves to continue serving life through their death, petrifying their own substance to make it a resistant and yet insensitive part of the body, a layer of death protecting life, nonetheless continues to evolve and is the subject of further experiments, driven by randomness or chaos but refined by life itself to select and nurture valuable discoveries. Almost all over the skin of the four-legged creature, a large number of similar protuberances then appear, which are far finer and softer than the claws found on the tip of its fingers: hairs.

The advantage offered by the first hairs was first and foremost an enhanced ability to perceive signs coming from the land, life, and the air, without direct contact with the skin. Our forefathers have indeed at this point conquered the dark hours of the night and have made them the time of their activity. Quite similar to the rodents to which we are accustomed, they dig burrows into the soil in which the brightness of the sun or the moon cannot penetrate, forcing the creatures to cease to rely on their vision and to favor other senses, touch in particular. Elongated whiskers allow

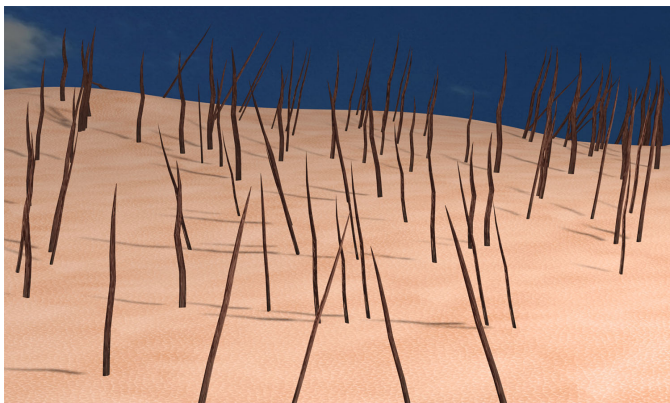


Figure 6.1: *Hairs.*

them to feel remotely, to sense the boundaries of the earth of living things without waiting for a collision. As they roam through the undergrowth in search of their sustenance, the scanty hairs found over their body amplify the sensitivity of their skin, increasing the response to sudden changes in their environments, such as a gust of wind stirred up by the rapid movements of a predator. Some of them survived because of this presence of hairs on their skin while others, not having been endowed with them, were torn apart by the teeth or claws of other animals, and as a result, the presence of hairs increased among their kind as the survivors passed on their gift to their offspring.

Anchored into the skin, in contact with the network of nerves pervading the body and gathering information from the earth, life, and the sky to bring it to the creature's world, every strand of hair is an extension of these nerves, one that is itself lifeless and senseless, a part of the earth and death, but that faithfully serves the whole of life. Their presence is nonetheless far from uniform. The soles of their feet are totally devoid of them, as they would impair movement without providing any advantage in return, and thus those having hairs there have slowly been out-bred by those not having them. Hairs are probes sent by life to explore and occupy the air, the celestial expanse and the fluid filling it. They are the fruit of an attempt by life to interact with the heavens and gain a stronger position as it faces them. These hairs are themselves earthly, dead matter, parts of the earth used by life as spears defending it from the forces of the skies and by individual

creatures to resist the aggression of other lifeforms through the warnings given by this vanguard. They therefore have no place on the surfaces that serve as an interface between the living being and the earth: the sole of its feet, the palms of its hands, among others. Through countless trials and mistakes, life finely trimmed this coat of hairs, clearing the areas of the body where such hairs would prove to be a disadvantage. The way to the main sensory organs must generally be clear in order for them to function properly: the eyes, the snout, the mouth, the ears, are relatively free of them. In contrast with this, the succession of generations upon generations of hairy creatures has shown to life that a denser coat on the rest of the skin would present new benefits to these animals, marking the appearance of fur.

Our ancestors were, at this point, creatures of the night, and as they relied on their own forces to produce the heat necessary for their life to continue while the sun's face was veiled by the earth, they suffered and were exhausted by the icy breeze of the darkest hours or the coldness of the frosty dew of the winter covering the blades of grass caressing their skin as they foraged for food. The patchy hairs on their skin, first used for information, then began to give them a new advantage. The denser their coat, the warmer did they stay during the nighttime, the hours of their toil for survival. Those endowed with thick coats then needed far less energy than the other members of their kind to maintain their flesh at a constant temperature and therefore could either survive with fewer resources or employ their wealth of precious nutrients for other purposes, such as asserting their dominance on others, finding a mate, or protecting their offspring.

From a scattered array of extensions of the skin's nerves, hair thus become a furry envelope enfolding the animal. They become an insulating layer separating the living creature from the earth and the sky, artfully allying and interlacing earthly strands of hair with the air filling up the sky. This layer does not really belong to life, as it is made of dead matter and air, but it neither truly belongs either to the earth or the sky. Marrying the realms and blurring the lines separating them, this layer, fruit of life's patient and relentless work of exploration of its own nature, will be a new shield, a more sophisticated and versatile evolution of the hardened skin and scales. Its role will nonetheless not be limited to preventing the theft of the body's heat by the winds, the rain, or

Figure 6.2: *Fur*.

the snow. This shield will be as efficient to keep things from going in the body as from going out. It will help the creature preserve its coolness as much as its heat, with the air filling up the sky. This layer does not really belong to life, as it is made of dead matter and air, but it neither truly belongs either to the earth or the sky. Marrying the realms and blurring the lines separating them, this layer, fruit of life's patient and relentless work of exploration of its own nature, will be a new shield, a more sophisticated and versatile evolution of the hardened skin and scales. Its role will nonetheless not be limited to preventing the theft of the body's heat by the winds, the rain, or the snow. This shield will be as efficient to keep things from going in the body as from going out. It will help the creature preserve its coolness as much as its heat, acting as true insulation, isolating life from the dangers that lie outside.

When presented with a dilemma, when it is torn by the need to satisfy contradictory needs, life often discovers a solution by dividing itself, cleaving part of its being so that each half would fulfill one of these needs. Such a dilemma earlier led to the emergence of complementary sexes, and complementary gender roles, for example. Here, our forefathers were faced with the need to preserve their body heat, which is produced at a considerable price for the creature, and life therefore endowed them with a coat of fine, short hair ideal for such a purpose. Another need nonetheless soon appeared

in their lives: the need to protect their insulation layer, filled with an interlaced array of hairs with air warmed by the body, from the dampness of the rains, or the violent radiance of the sun, to which the skin of the mostly nocturnal creature slowly grew unaccustomed. The coat of hair of the animal thus was scindred in two, with an array of short, soft hairs used to preserve heat and longer, thicker ones forming a secondary, outer layer protecting the first from humidity and the celestial fire. Through this evolution, this branch of the tree of life grew further in stature, able to resist an increasingly wide range of threats, such as the freezing waters of the boreal brooks, the parching heat of the desert sun, or the frigid tempests of the winter. Life is thereby able to penetrate deeper into the continent, pervading all the corners of the earth, with the descendants of these animals more numerous than the strands of their fur, and life covering the skin of the planet, insulating the earth from the sky and thereby serving as an interface between the two. Far more modest in size and power compared to the upper and lower realms, life nonetheless evolves toward an always greater capacity to stand up to them with the passing of ages and grow less dependent, relying more on itself, using its profusion of living things and patience as its strongest weapons.

Fur represents an incredibly efficient way to balance some of the various needs of the animals. The soft skin of the creature is protected by it, not only from the sun or the cold but also from the abrasion of the dust and sand carried by the winds. It may even, if its hair are sufficiently coarse and long, lessen the damage caused by the claws of an adversary. Fur is both a coat and a piece of armor, one that benefits from the flexibility and slenderness of hairs and does not impede the movements of the living thing wearing it. This warm layer, allying earth, life, and air, is nonetheless so well-crafted that it soon attracts the attention of other forms of life. Minuscule insects, themselves waging their own war for survival, attempting to find food while avoiding the threats coming from the earth, the sky, or other branches of life, will find in this fur a refuge, a home. Fleas are one kind of such inhabitants of the fur of our ancestors and cousins. They are one example of small, rudimentary creatures that have succeeded to live off the efforts and flesh of others, far more imposing and evolved than them, showing the complex nature of the tree of life, made of meandering branches interlaced with one another rather than a giant

pyramid, with the more evolved depending on lesser forms of life. The apparently insignificant and yet adaptable insects have been selected for their ability to cling onto the skin or the hair of the four-legged creature, feeding on its blood and using the beast as its protector and shelter, enjoying the warmth of its body, safe from those preying on its kind and from the rains and the winds that sweep the land. Both host and guests then strive against one another, as populations, resulting in a new round of selection. If the guests are too demanding and numerous, the burden placed by them upon their host will damage its health, reduce its capacity to find food and lessen its chances of finding a suitable mate and therefore also to give birth to new members of its kind. On the other hand, if the guests are not eager and daring enough to conquer this furry land and extract the crimson liquid flowing under it, they themselves will vanish. Life thus favors the discovery of a balance between the needs of the two branches of the tree in contact with one another.

As the most widely visible part of the creature's body, its coat of hair will furthermore begin to play a role of choice in its world. Its color may at times be chosen by life because of its influence upon the coat's efficiency. A white coat would indeed be ideal to counter the threat caused by an overabundance of the sun's rays, reflecting these envoys of the star away from the body and preventing their heat from threatening the life inside it. On the contrary, a black fur would absorb more light and more heat, thereby giving a helping hand to a creature endangered by frigid winds or the coldness of a damp soil. A coat sharing its color with the surroundings of the animal may also allow it to move stealthily, avoiding predators and death, and as a result, some of them will evolve to change their coat according to the seasons.

The radiance of the incandescent star is nonetheless also the source of a more indirect effect, as its light, by illuminating the creatures' eyes and its world, also invites the emergence of interpretations concerning the color and patterns displayed on the coat of fur, the appearance of meaningful signs perceived by their peers and shared inside their world. This emergence is once again the fruit of the intelligence of life itself, through the play of attraction and repulsion, affinity and strife, love and war, rather than the invention of particular individuals. None of them defines the meaning of a precise pattern, but it nonetheless emerges naturally,

as these patterns and colors are correlated by life with factors affecting their fitness, their ability to survive and give birth to a fit offspring. This mechanism of emergence of meaning is both simple and subtle, elegant and crude. A bright-colored coat may attract the eyes of predators, but it may also attract the attention of a mate, and increase the willingness of the partner to perform the life-giving ritual of love. A precise pattern may also allow the members of a group to identify members, tightening the bond between them and facilitating the identification of intruders. It may thereby provoke wars as much as it can kindle love. The world of the creature thus finds itself filled with new signs, inscribed with colored hairs on the body of the animals, bearing a meaning whose origin is lost in time, but which is nonetheless shared by a community, helping its members survive and perpetuate their bloodline.

Re-flection: The Hair Covering Us

Life obstinately advances through time as the earth under it revolves around the luminous sphere of gold, caught in a seemingly eternal ballet taking us to the frontier of the cosmos in the arms of a galaxy. The tree of life taking roots in the earth nonetheless appear to be alone, surrounded by death from all sides, perpetually under threat of being absorbed by it, seeing this wondrous fire fading away in the darkness.

Life thus slowly learns how to stand up to this omnipresence of death around it, defending its existence, and notably turning the weapons of death against itself, using the earth to fight the earth. Enshrouded by the cadavers of formerly living cells, in the form of a thin layer of dead skin or nails, our body makes use of dead, earthly matter attached to us to protect our life and delay our return to death.

This movement of exploration of life continued as our ancestors conquered the dry land and the nighttime, and new, minute outgrowths of dead matter sprouted out of their skin, some of them proving their usefulness. Thin and long strands of dead matter formed the whiskers of our nocturnal and earth-dwelling forefathers, and allowed them to feel without direct contact, avoiding collisions and enhancing their sense of touch.

Softly touching the hairs covering our limbs, we can feel the role they play in the sensitivity of our skin. We are also invited to notice the distribution of these hairs on our body, where they are present or absent. Covering most of our scalp, our head is without a doubt the place where most of our hair are located, and we may imagine how long they would be if we had refrained from cutting them since our youth.

Allying air and earth, both part of death, the hairs on our head are like a coat of fur, a natural headgear, and its purpose is here not to amplify the senses, but on the contrary to insulate life from death. This hat has a great versatility, as it retains the heat generated by our body through the burning of nutrients, but also prevents the radiance of the sun from hitting the skin of our head or the winds from blowing on it. Isolating life from death, the body from the forces of nature, hair help us keep our temperature balanced.

Observing our face, other uses of hair by life to increase our adaptation to the land may become clear. Our eyebrows and eyelashes are indeed precisely disposed to protect our eyes from the light of the sun, intercepting its rays descending from a high angle and preventing them from blinding our eyes. The hairs in our nose, on the other hand, act as a filter for the air on its way to our lungs.

Looking at the faces of the men and women around us, we may also notice the differences between the hair of both. The beards of men enlarge their faces, making them appear more impressive, more virile, whereas the hairless face of a woman appears more delicate, more feminine to most eyes. Hairstyles now also bear meaning and they influence the play of attraction and repulsion, love and war, inciting us to care for them, spending time and money to trim or dye them to catch and please the eyes of others.

The furry coats of the animals populating the open country are also painted with meaning, patiently drawn by life through the ages to endow those wearing them with the qualities they need to live. What we choose, nature chose for them, giving some a vestment made for stealth, to be invisible, while others are covered with bright and beautiful patterns offering them the favors of the fittest mates. Contemplating these artworks of nature, we may ponder the advantages they provide to those bearing them.

Looking at our naked body in a mirror, noticing the patterns of hair drawn by life upon our skin, we may also wonder about the role they play in our lives and how they influence the way others see us. When we decide to change this picture painted with the strands from which brushes are made, we may ask ourselves why do we deem this gift of nature insufficient, needing improvement?

Chapter 7

Drink of Life: Breasts and Milk

At this point in the history of our bloodline, the dry land is now ruled with razor-sharp teeth and dagger-like claws, which do not belong to our ancestors, but rather to an offshoot of the branch of the four-legged, egg-laying creatures that first step foot out of the ocean. This offshoot is the dinosaurs, the “fearful lizards.” Some of them, equipped with the aforementioned nature-given weaponry, feast on the flesh of all the animals that fall into their grip, while others devour leaves and grasses, the light-harvesting hands of life, to sustain themselves. Caught in the battles between these creatures, often having a more imposing stature, our forefathers then lay low, dwelling the shadows, roaming under the moonlight, thereby occupying an inconspicuous niche, ensuring the sustainability of their existence and of their bloodline, living far away from the battlefield filled with daylight and giant beasts, a niche that they discovered through their ability to control their body temperature.

An important factor allowing the creature to gain control over its own internal temperature is, as seen in the previous chapter, the complementary use of fur and sweating. The newborn nonetheless comes naked into the world, without the coat of hair that would later protect it from a cold breeze or the dampness of the soil. In the darkness of the den where they spend the first part of their life, these newborns would therefore instinctively seek a source of

warmth, like flowers turning toward the sun to collect its brilliance. They burrow under the belly of their mother, using it as a cave, a shelter from the cold air, and in close contact with the warm coat of their parent and its even warmer skin under it. Just as living things take refuge inside the body of the earth to escape the wrath of the sky, the newborns find a haven of warmth and safety under the motherly womb out of which they were born. A whole litter may dwell in this living shelter, and as the body heat of this family is pooled together, that is, as its members share this precious resource to ensure the survival of the group, the mother may find herself in need of a cooling down of its skin. Its underbelly then becomes soaked with sweat, in an attempt by the mother's body to alleviate the discomfort brought by her progeny. The young, on the other hand, are thirsty and hungry, unable to feed themselves or even to masticate and digest food that would be laid at their feet. Their mother may have helped them with this work of mastication, feeding them directly from mouth to mouth, but such a task would have taken considerable time and demanded great effort. Confronted with this freshly secreted sweat soaking the underfur and the skin of these young, they promptly proceed to lick this liquid, which not only contains the water that they need to quench their thirst, but also other elements that can be used by their rapidly developing bodies.

Not needing to wait for their mother's care to quench their thirst, the newborns having discovered this spring of living water grew more resistant than others of their kind. They escaped the claws of death in greater numbers and thus had a more numerous descendance, leading to a spreading of this trait among the population. This innovative method of feeding was soon refined by life. The coat of fur grew shorter and shorter in the underbelly, and in particular in the spots where the young licked the sweat. The less fur in these spots, the easier it was for them to drink the precious fluid, and less was wasted by returning either to the soil or to the air, avoiding a weakening of the mother through the draining of her supply of water and other substances found in the sweat. Patches of naked skin therefore began to appear, coming in approximately the same number as the young belonging to one litter.

As the sucklings grow in size and strength, they grow more independent from their mother, leaving her bosom for increasingly

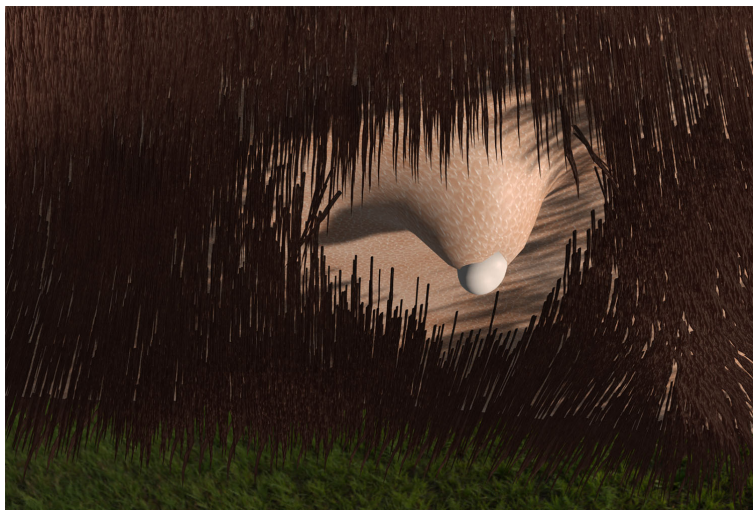


Figure 7.1: *A teat.*

longer periods of time. When they return to her side to drink their fill from the motherly spring, locating the patches and maintaining their mouth onto them is rather problematic. Many probably failed at this arduous task and starved as a result. Among the population, some of the mothers nonetheless began to be endowed with patches slightly protruding from their belly, facilitating their localization and helping the sucklings hold on to them. These children survived in greater numbers than others, and a selection thus continued, favoring increasingly large protuberances. The patches then turned into teats, discovered by life through trials and errors, ideally suited for the feeding of children who have yet to be able to eat solid food.

Access to the maternal liquid is nonetheless not the only factor affecting the sucklings' capacity to escape death and extend their bloodline. The composition of this liquid is also the subject of a crucial process of experimentation by life. The sweat of the animal initially provided water and perhaps a few minerals such as salt, helping the young to survive. The mother, who drinks the water found in stagnant puddles, ponds, or rivers, indeed purifies the liquid as it is incorporated into its body, and as a consequence, the sweat drunk by the young is devoid of any impurities, free of parasites and bacteria that could threaten the health of these juveniles. The maternal drink is nonetheless at this point far insufficient to

sustain the rapidly growing bodies. They need a steady supply of the most fundamental building-blocks of life, nutrients that will both form the bulk of their mass and power the edification of their body, the incessant and incredibly intricate weaving of a myriad of substances and the building of unfathomably elaborate structures, necessary for the prolongation of their existence.

With the performance of each ritual of love and the birth of new individuals, the composition of the maternal liquid is nonetheless the subject of minute alterations. Life once again explores the possibilities offered by the features it discovered in the past, such as the use of sweat to feed newborns. Among the vast palette of new drinks brewed in the mothers' bodies, certain recipes are found to provide an edge to those having drunk it during their infancy over others. When sugars, in particular, are integrated into the sweat, the sucklings grow faster, stronger, and tend to more infrequently see the fire of life animating their flesh be quenched. Sweat thus slowly turns into milk, as those who are offered a richer beverage are more able to survive infancy and later give birth to a large descendance. Life then continues its work of experimentation, incorporating a large spectrum of substances into the nutritious potion. Some of them are at times found to be poisonous, decimating those drinking the liquid, but these unfortunate blends swiftly disappear. As the mixtures that do not help the sucklings survive and reproduce are eliminated, while the beneficial melanges are preserved, life therefore slowly but surely refines its recipe, finding a perfect blend allying various nutrients with substances helping the young creatures resist the assaults of the most minute forms of life that could invade their bodies.

The composition of the milk is nonetheless also the subject of a tension, between the needs of the mother and those of her offspring. The more she gives, the less she has. The more she sacrifices herself, on the other hand, the more likely it is for her progeny to overcome the dangers of infancy, ensuring that her bloodline would be extended for more generations and grow in numbers. An excessive weakening of a mother, offering all that her body needs to her sucklings, may nonetheless also endanger them, as she needs to remain healthy before her children reach the age of their maturity and independence, when they would no longer rely on their parents for nutrition and safety. Life therefore finds a balance between these two constraints, conciliating the needs of



Figure 7.2: *Nursing mammals.*

both mother and child, reaching a point of equilibrium that would represent the best compromise for the prosperity of their kind.

The nursing of infants is the exclusive duty of the mother. The father may have the same protuberances as her,¹ but he usually does not possess the milk-producing glands under them. This distribution of duties between the sexes further increases the gap between the needs of the two members serving as the seed of a family. The mother already was impaired in her daily activities by pregnancy, which drained her strengths, impeded her movements, and demanded that she consume more food while being less able to find it outside of her den. The father already had to compensate for this impediment, by being stronger, bigger, faster, so that he could secure food for the whole family, ensuring the extension of his bloodline, the passing on of his library of information, his identity. Nursing prolongs the period during which the mother has to devote her time and her flesh to her young, forcing the male to continue to assume the role of provider and protector. The bond between mother and child is tightened by this extended intimacy, with this bond not limited to a close contact of their skin but also to the drinking of her very essence. Affection can be nurtured within the home, while war is waged outside, by the father who

¹Hormonal imbalances, natural or artificially induced, may even cause men to lactate.

prevents predators from reaching them, and lovingly brings the fruit of his hunt or foraging to the familial lair.

Another tension nonetheless emerges within their kind. A larger size may provide an indubitable edge to a male, who will more easily defend his family and be able to find food in a land filled with competitors, but if this was the only factor, their kind would relatively quickly grow to become enormous beasts. For the female, on the other hand, a smaller body size is a sign of fertility and fitness of offspring,² and for this reason, the most desirable, bigger males will tend to want to mate with females of more modest stature. The opposition between these two factors leads to the reaching of an equilibrium, as by reproducing with the bigger, the smaller female will give birth to average-sized children, favoring a stable stature among their kind, even though other factors may lead to a breaking of this equilibrium.

The strengthening of the bonds between mates on the one hand, and between parents and children on the other, contributes to the hardening of their branch of the tree of life, making it more resistant. The triad that they form behaves like an organism, and it is subjected as such to the play of affinity and strife, love and war. Altruism between the members of this triad may be favored if it benefits the whole, even if it comes at the detriment of some of its members. As it is the case between the cells forming an animal, individuals may leave behind their survival instinct, calling them to propagate the fire of their life beyond the horizon of their own death, kindling new fires carried by a new generation, so that the structure to which they belong may prevail over its competitors, vanquish its enemies, and see its branch of life split into a myriad of new shoots. Larger communities, colonies gathering several families, may have appeared at this time, sharing underground dwellings and part of their resources.³

Despite this unity of the members of the triad, the bond between mother and child remains stronger than others, probably

²Among humans, women with a slightly lower than average height seem to be the most fertile. See: Daniel Nettle. "Women's height, reproductive success and the evolution of sexual dimorphism in modern humans". *Proceedings. Biological Sciences*, vol. 269, no. 1503, Sept. 2002, pp. 1919–23

³See: Lucas N. Weaver, et al. "Early mammalian social behaviour revealed by multituberculates from a dinosaur nesting site". *Nature Ecology & Evolution*, vol. 5, no. 1, Jan. 2021, pp. 32–37.

because it is the most crucial one for the survival of the bloodline. Reflecting the nature of life itself, this bond must be subjected to the play of attraction and repulsion, affinity and strife, as it is through the play of these poles that life progresses and prevails over death. The love of the mother for her children is manifested by her sheltering of the newborn close to her skin, by her offering her milk to satiate their thirst for water and hunger for food. If this were to go on indefinitely, these children would nonetheless never reach adulthood. They would never gain the skills and strength allowing them to face by themselves the dangers and challenges presented to them by the earth, by life, or by the sky. They would die of hunger when their mother would cease to provide for them, because of exhaustion or simply death. They would be slaughtered by the sharp-clawed creatures dominating the dry land. The bloodline of the entire family would thus be brought to an abrupt end. The time of affinity thus must give place to a time of strife. Attraction must give place to repulsion. This is why when the appointed time has come, one decided once again as the result of countless trials and failures by life, the mother begins to wean her progeny. She denies them the milk that they crave. She rejects them when they crawl under her belly. The prosperity of their bloodline will depend on the efficiency of this rejection, which should be as intense as the love she showed her children before. As the earth and the sky nurtured the evolution of life by submitting it to numerous trials, numerous pressures forcing it to discover a way of overcoming them, the mother pushes her children away, so that they would be compelled to strive for their survival, thereby learning how to gain their independence and stand up to the forces of nature. Through this play of love and strife, the child is taught the value of his existence, or is condemned to perish, leaving his place to one of his siblings.

The suckling lives in an extremely limited world. His existence gravitates around his mother, source of warmth, source of food, source of security. His eyes may be opened, but in the darkness of the den, the nature of what surrounds him has little importance, as he does not need these things to survive, but only his parent. Weaned from the maternal breast, the young is forced to discover the earth upon which he is thrown, the life to which he belongs, and the sky by which he is enfolded. He slowly builds up his own world from this torrent of information poured inside his brain by

his senses. He discovers what he needs to survive on his own, either through instinct or the guidance of his parents. The milk that fed him until now was a liquid of life, a watery fluid whose ingestion demanded no effort, no skill, a mixture of watery earth and bits of life, substances weaved by living things using both earth and sky. Now, he is compelled to get acquainted with solid food, that is, food that contrary to water, which combines the fluidity of the air with the high density of the earth, may resemble more to the earth than to the sky. The child indeed gorged his belly with milk in the same manner as he fills his lungs with the air of the heavens, both being perfectly fluid, opposing no resistance, letting themselves be taken and absorbed without opposition. The plants, fungi, or animals from which he will now have to extract his sustenance are nonetheless not so. The thick fibers of the plants will need to be broken and masticated before they can be ingested. The bones of other animals will have to be crushed before the marrow inside them or the flesh around them may enter his stomach. Learning to handle the eating of these earthlier kinds of food is the first step of the young animals toward adulthood, toward the moment when they will be able to stand up, not only to other parts of life, but to the earth and the sky themselves. The weaning, consequence of the rejection of the mother and manifestation of the complementary tension to the one of love, therefore leads to a strengthening of the young, a fortification of the family, and thus also to a regeneration of the tree of life as a whole.

The emergence of the suckling period had a profound effect on the development of our ancestors, who from this point are technically designated using the name of the milk-producing part of the mother's body, *mammals*. These milk-fed infants, recipients of the devotion of their mother, can be born at an earlier stage of their development, at a time when they would not be able to feed on their own. Rather than shortening the length of the gestation, life nonetheless discovered that a prolonged development, continuing after birth, would provide invaluable benefits to these creatures. Fed with a nutritious nectar whose recipe was finely tuned across generations to perfectly fit their needs, these children are not only given more time to grow, in sophistication as well as in size, but also offered more resources to do so. More daring experiments could then be made, investing more nutrients and time to unlock new secrets of life.

This movement of extension of the infancy of the animal was further intensified by another discovery made by these creatures. A pouch enclosing the unborn emerged within the womb, one that would serve as an interface between mother and child, mainly allowing her to feed and offer oxygen to him during the later stages of the pregnancy, in addition to various exchanges to and fro between them, such as waste removal. This pouch, the *placenta*,⁴ allows the gestation to continue for a longer period, beyond the point when until then birth was a necessity, due to the increasing needs of the growing young, which could not be fulfilled inside the womb. The extension of the development of the creature thus occurs both inside the womb and outside of it, before and after the birth of the child. This occurred because it led to the birth of fitter children, which were therefore selected by life and soon outnumbered their cousins.

Because of this more patient development, the unfolding of the body-plan contained in the library of information of the creature, from the first seed-cell to an adult animal, can be more convoluted, demand more time, and use more resources. As a result of a considerable number of experiments, life then discovered that a greater investment in the development of the brain, in particular, would be rewarded by a greater ability of the children to extend their bloodline. The skulls of their kind would soon be enlarged, as the individuals offering more space for the brain to grow would show greater skills to cheat death and give birth to numerous children. Subjected to other constraints limiting the growth of the head, the brain then began to fold upon itself, continuing to evolve within the walls formed by the cranium. Although brain size is not always correlated with intelligence, it is probable that it was here the case. Their senses were probably enhanced, and part of the bones of their jaws began to form parts of the inner ear. Signaling between the members of their kind in all likelihood became more refined and grew in importance in their lives.

It is at this point that an event that would change the course of the growth of the tree of life forever occurred, one that marked the end of the reign of one of its branches, which was almost entirely cut off, and the rise of another. The dry land is then the dominion of the “fearful lizards,” better known by their Greek name of *di-*

⁴From the Latin “placenta,” meaning “flat cake.”

nosaurus. Some are tall as trees while others could fit into one of our hands. They are the apex predator of the time, reigning over all the creatures of the land, who live in fear of their teeth and claws. Our ancestors lived in their shadows, dwelling in the entrails of the earth and venturing outside only when the sun retreated beyond the horizon and they could hide behind the darkness of the night, when many fearful lizards were sound asleep. These dreadful beasts nonetheless encountered a superior force, one coming from the sky rather than the earth. A fiery rock, the size of an entire city and traveling at lightning speed through the highest skies, ended its course by piercing through the ether enfolding the earth and crashing into the rocky surface with an astonishing force. It vaporized what it encountered and itself was shattered into an innumerable number of pieces, scattered throughout the air and the land. This impact would have been so intense that it would have ejected a prodigious amount of pulverized rock, dust, and ashes into the sky, creating an opaque layer separating life from the heavenly brilliance. Trapped under this sooty cloud for probably more than a year, the tree of life as a whole was put under enormous pressure. The very basis of its growth soon crumbled, as the light-workers, upon which the whole pyramid of life rests, were starved of light and vanished from most of the face of the earth. All the creatures depending on them for their sustenance then also perished, as did the predators of these animals. The seas and the land were poisoned with this soot raining down from the sky, as the surface of the planet gradually became colder and colder, deprived of the warmth of our star.

The tree of life was then severely trimmed. Entire branches were cut down by this fire from the sky, and the size of others was greatly reduced. Most of the species of the seas perished, and on the dry land, it was soon found out that an imposing size may be a considerable disadvantage when the times of hardship come and resources are scarce, no matter how strong and feared you are. The greatest of the fearful lizards, whose gigantic bodies required an incredible amount of food, could simply not be satiated on this desolated earth, on which every single species was desperately trying to survive this reign of darkness and cold. All the creatures larger than a common dog vanished as years or decades of disruption followed one another. The animals of modest statures, like our milk-fed ancestors, were already well-equipped to handle this

long winter, with their underground burrows, their warm blood, and their coat of fur. They could feed for months on the decaying vegetation or small insects when this event occurred, and then, as the rays of light once again reached the earth, more violently due to the destruction of some of the protective layers of the atmosphere, they could feed on the budding plants, their skin protected by their coat.

Among the fearful lizards, only the smallest remained. They would nonetheless take their revenge upon the sky that brought an end to their reign over the dry land, as they would later form one of the largest new branches of the tree of life, the birds, conquerors and rulers of the lower skies. For our ancestors, this catastrophe was nonetheless a blessing in disguise. The annihilation of the largest predators left a power vacuum, and our ancestors suddenly found themselves at an advantage, with their ability to thrive in the cold, whereas other branches of life, such as the remaining fearful lizards or the largest insects were less predisposed to a perpetual winter. Striving against dangers while lovingly bonding with their ascendants and descendants, the milk drinkers soon overcame their competitors. When the sky was finally clear and the earth recovered from this strenuous event, their ability to prolong the development of their young, both before and after birth, was used to produce larger children, filling the vacuum left by the fearful lizards. Our ancestors began to grow in stature and in diversity, and they soon made the dry land their dominion, towering over the over branches of life and submitting them to their rule.

Re-flection: The Drink of Life Within Us

Every single living thing that ever lived emerged into being through the flesh of another, as the fire of life is propagated with direct contact, with new sparks kindled by touching the blaze. Many of our ancestors nonetheless matured inside eggs and were born into the world alone, discovering the land or the sea without the help of their parents, left to fend for themselves.

Life then learned the benefits of greater bonds between parents and offspring for the whole of life, and thus we can observe the birds in their nests brooding or feeding their chicks directly from mouth to mouth. Such bonds are even more developed among our kind and our close cousins, particularly the one between mother and child, as she bears the new sparks of life in her womb until birth and feeds the resulting fire from her breasts.

The experience of our coming to being has never left a sufficiently deep trace in our mind to be recalled, but we have seen the birth of others, witnessing how the infant is promptly placed on his mother's breast. Feeble and cold as its moist skin is exposed to the air, it finds solace in a warm and tender embrace, and instinctively reaches out for a nipple with its mouth, with the hope to satisfy the hunger of its growing flesh.

Placing one hand under our clothes, we may touch the part of our body made to feed newborns. If a woman, the mass of the milk-producing tissue appears soft but heavy, needing support to prevent discomfort, but both sexes are endowed with nipples, apparent and protruding, tailored to be seized by a newborn's mouth. The control of the feeding is shared by both mother and infant, as the progenitor gives access to the nipple, but this bottleneck of the body needs suction in order for the liquid of life to flow out of it.

It is no coincidence if the milk-producing tissue appears prominently on the naked body of a woman, and if men have developed a particular interest in this body part while searching for a potential mate. Observing the ample cleavage of a woman, revealing voluminous breasts, men are naturally aroused, just as a woman would be if she looked at the frame of a strong man, with bulging muscles all over his body. Both traits are indeed signs of fitness in the play of love and war, with the breasts indicating abundant milk,

and the muscles showing that the man would be able to defend a mother weakened by pregnancy and breastfeeding.

If the newborn is taken to the breast of his mother, it is nonetheless not only to quench his thirst. Enfolded in her arms and lying on her body, skin against skin, the baby is also offered much-needed warmth. He is also given a sense of security that would prove to be crucial for the healthy development of his mind. This location is also the safest one that she can offer him, as she can fold arms and legs to cover him, preventing the blows of enemies from wounding his flesh or shielding from the chill of the winds or the rain.

Observing a mother feeding her child, we may consider the sacrifice she makes to extend the reach of her being, as she uses her resources to allow this new life to grow and mature, having received half of its essence from her. We may also look at the father of this child, and see if he plays his part to support his weakened partner, either ensuring the protection of his family or providing for them, with assistance or resources.

The bonds patiently weaved between mother and child during the first few months are particularly strong, and even if one's parents have not adequately performed their duty toward their offspring and life itself, we are compelled by our nature to maintain a connection with our progenitors, and mend this bond if needs be. Caring for our children, we may keep in mind the importance of this bond that begins on the motherly breasts.

Chapter 8

Life in the Trees: The Early Primates

The earth has now long recovered from the apocalyptic event that ended the reign of the fearful lizards as a tempest of fire and ashes enfolded its surface, turning large parts of life into death, drowning countless creatures in darkness and condemning them to starvation. The dry land is once again covered in dense forests, watered by the heavens, teeming with creatures competing for the love of a mate and fighting against everything else, against their peers, against death, and even the earth and the sky. Songs of love resound together with shouts of rage under the canopy, as our ancestors struggle to adapt to the new order of their world. The earth has changed, and it continues, as the great continent gathering all the dry land has now been broken into several plates, drifting from each other at the pace of the walk of the smallest creatures. Branches of the tree of life will now grow separated from one another because of this scattering of the dry land, and many will only once again enter into contact with their distant cousins through the agency of man. Our ancestors also continue to change in reaction to the guidance of the earth, life, and the sky. The challenges of the present, offered to our forefathers as a series of trials, pave the way for the blessings of tomorrow. The hardships of nature are the gifts that allow us to overcome our limits and reach our destiny.

Under the emerald blanket covering the land, the thick canopy

made of innumerable leaves collecting the precious envoys of the sun who will drive the edification of life as a whole, the animals weaned from the nutritious milk offered by their mother wander on the soil covered with the withered remains of plants having departed from life, mainly in search for small insects. Many of these insects are now populating the heights of the canopy, climbing the coarse bark of the tallest trees by infinitely minute steps, patiently ascending toward the heavens, or more exactly, toward the safety that goes together with the solitude of the most inaccessible places, while their cousins simply soar above the forest, frenetically beating their wings to counter the pull of the earth. The floor of the forest remains the domain of the larger creatures, whose impressive stature is both what made them lords of the dry land and now what also prevents them from leaving its surface. Their legs are short and their body sturdy. When they attempt to follow the climbers on their wooden paths, they fall, pulled back by the earth, which is like a jealous mother, unwilling to let her children go see their other progenitor. The earth keeps life close to its skin, resisting the attempts by life to embrace the sky, only letting slip the most modest forms of life through its clutched fingers. When the mightiest creatures are made to fall by the gravity and jealousy of the earth, they often also are led away from life and back to death, their substance decomposed by the flow of time seeping through the skin of earth, their bones lying on the floor and their blood watering the soil.

Our ancestors may thus have remained close to the earth, submitting to the pull of the great body out of which all life arose, but another force countered this downward attraction, one whose exact nature remains mysterious, but nonetheless guided our distant mothers and fathers to a path that would lead them upward, away from the surface. This force was not one canceling the pull of the earth, a mere counterweight coming from the heavens, but rather one acting on a different dimension, affecting life from the inside, pushing these creatures to resist the power of the earth in order to survive and see their bloodlines be extended. It may have been the presence of predators on the ground of the forest or the absence of sufficient amounts of food, as life both penetrated deeper into the soil and reached higher into the air, leaving the planar home of life somewhat deserted, only used as a support for the trunks of the trees, pillars of these temples of life caught between the bright



Figure 8.1: *A modern lemur.*

heavens and the dark abyss. What is known is that our forefathers soon joined this race toward the sky. Life left behind those whose limbs were too weak for the ascension, those who lacked the agility demanded of those daring to climb the wooden pillars of life. Their bones shattered on the ground, their bellies empty, or under the claws of their opponents, they died at the feet of the mighty trees. A few of their kind nonetheless survived and even prospered. They had lean bodies with limbs and fingers slightly longer than their peers, allowing them to sometimes be successful at climbing some of the lowest trees of the forest. These agile creatures found relief from the force pressuring their comrades below because of their unique ability, and they thus remained part of life while others were reclaimed by the earth. The passing of generations only increased this evolution, as the enigmatic force was still very much present, no matter whether it was one impairing those wandering on the ground, pushing them away from the floor or rather one pulling them up toward the canopy, in the heights where delights of the palate may have then been discovered. The paws slowly turned into hands, the front legs into arms, transforming the appearance and mechanics of the creatures, which now looked somewhat similar to the lemurs of the island of Madagascar, living relics of our distant fathers.

The elongation of the arms, legs, and fingers occurred together

with a radical transformation of the way by which these creatures moved in their environment and appropriated it. It initiated a revolution within their world, as the surface upon which they move is now no longer the mere skin of the earth, a two-dimensional, irregular plane. The living trunks and branches of the forest, in which a sap of life restlessly flows, become the paths trodden by their feet, the ladders with which they elevate themselves, away from the dangers of the earth and toward the blessings of the heavens. A new dimension appears to be opened by the trees, as each one of their branches opens up new lanes that can be followed, allowing the exploration and occupation of new parts of the upper realm. Traveling on this intricate network of intertwined pathways allows all those strong enough to resist the pull of the earth, or small enough to not be significantly affected by it, to walk across the three dimensions of the sky, within the boundaries of this vegetal web. Our ancestors are thus offered a valuable present by their very distant cousins, the trees, as they rediscover motion through the third dimension, which was known of their marine forefathers but whose knowledge was lost as they waded out of the shallow waters to conquer the dry land, submitting themselves to the pull of the earth and a life limited to its surface, as a price to pay to enjoy the safety provided by the then deserted land.

As the most agile members of the population are continuously selected by life, the legs of their kind become stronger, with faster movements. They then not only climb the trees, clinging on the bark with all their strength to avoid falling to their death, but now can also leap from branch to branch, from tree to tree, unafraid of the brief instants in which they find themselves without the support of the trees, free in the air and now skilled in the art of countering the pull of the earth, which continues its constant attempts to bring them back to the earth, and back to death. They jump with their feet and find balance with their arms, exhibiting an exceptional level of coordination of the countless parts of their body, a genius of reactivity, an ability finely tuned through generations, as life rewarded the agile and crushed the clumsy.

The challenges of such three-dimensional motion from tree to tree furthered the selection of these creatures. Many fell to their death because of minute misjudgments of distances of branches or of their robustness, and as a result, their kind grew wiser, more prudent and attentive to the signs of the forest. The flow of in-

formation poured by their senses into their mind was intensified by their new habitat, and the greater dangers that it presented led them to reap greater rewards, as their kind was trimmed of its most unfit elements while the best specimens were exalted by it.

The elongated limbs nonetheless allow more than the invasion of the canopy, a departure from the earth. The young could now hold on to their mother with their arms embracing her body and their fingers clinging to her hairs and skin. Burdened by their weight, she nonetheless could now prudently venture around in search of food. The movement of independence of life from the earth is thus here furthered, as the newborn no longer needs to be laid on the earth. The mother now keeps them close to her flesh, skin against skin, life against life, shunning the earth that now only is seen by them as the basis of the giant pillars of life forming the backbone of the middle realm, the trees whose roots are anchored deep into the soil, marking the boundary between life and earth, and whose branches are extended toward the heavens, delimiting the frontier between life and the sky. In addition to opening the living space that they now occupy, the trees also offered something else to the climbing creatures, something whose presence may very well be the main reason for their ascent from the floor of the forest: fruits.

The trees, like every other part of life, strive as species to survive and extend their (sap-)line, overcoming the challenges presented to them by the earth, life, and the sky. Sharing the same piece of land but confronted with different hardships, separate branches of life discovered ways of serving the interests of one another, forming invisible bonds that would make the efforts of the individuals benefit the new whole that they would form. The trees have no arms and legs and are unable to scatter their seeds to conquer new lands on their own. They nonetheless are light-workers, able to build life from the soil and the air when the sun blesses them with its radiance. A partnership thus arose naturally between trees and animals, with the first enclosing their seeds inside a pouch of sweet, nutritive flesh, and the latter taking upon the task of dispersing these seeds after having eaten the fruits, first carrying them in their belly and then dropping them on the floor as they defecate, incidentally giving them the fertilizer they need to germinate. As this alliance showed its efficiency, benefiting both animals and trees, the flesh of the fruits grew in size and nutritious

value, sustaining more animals, who would in turn disperse more of their seeds. This virtuous circle was crucial to the development of our ancestors, as they now had access to an ample supply of food, without the need to roam the vastness of the forest in search of insects, saving their strengths. The trees offer their gifts always at the same place, the same time of the year. This constancy and ease of access nonetheless itself poses new, unique challenges. The territory where these gifts come in profusion becomes the object of strives, between species, between groups, and between individuals.

The trees are now the homes of our ancestors. They are also their field and their granary, which must be defended and fought for. This predicament favors the weaving of stronger bonds between individuals, but bonds that may come as the fruits of strife rather than love. Hierarchies emerge within colonies, with the one able to assert his authority over the others leading and reigning. Those prevailing during the strife also enjoy the spoils of war, setting the tastiest food as their property, and selecting the fittest mates as the object of their love, while the others divide what is left among themselves. They seldom need to touch the ground, but already split the earth into parcels, territories that they consider their own. As life grows in independence from the realms above and below, consolidating itself by relying more and more upon its own strengths, it grows bolder, surer of itself, thinking of itself as equal or even superior to the earth and the sky.

These remote members of our bloodline dwelt in a cocoon of life, a forest sheltering them from the heat of the sun and protecting them from the cold wetness of the earth. As the sea also represented a cocoon inside which life was nurtured by the earth and the sky, preparing it before it could emerge and conquer the dry land, the forest may be seen under a similar light, as an environment guiding some of those dwelling in it toward a new stage of their evolution. They are housed by the trees, diligent servants of life, using the leaves as roofs, the trunks as walls, and the branches as countless meandering pathways leading them to every part of their land. This extremely stimulating environment, built with life and teeming with living things, continues to shape their body with each new generation, demanding more abilities from our ancestors, and as a result favoring the emergence of new abilities through selection.



Figure 8.2: *A modern monkey.*

The trees offer their succulent fruits to all animals, but unless one waits for them to fall on the ground, these savory treasures hanging on the branches are not so easily accessed. The fruits escape the mouth of our ancestors when they attempt to grab them with their mouth, balancing their body with their arms and legs on the branch. The nectarous gifts must be picked with their hands and held close to the mouth before they can rejoice their palate and satiate their hunger. The vital nature of this exercise renders the selection severe. The undexterous constantly drop their meals and lose them to the creatures occupying the ground, while the nimble-fingered have enough to eat their fill and even provide for their loved ones. A crucial discovery was the benefits of opposable thumbs, as the individuals endowed with thumbs placed lower than other fingers on their hands were found far more dexterous than their peers, which contributed to them having a larger descendance, thereby propagating this trait among their kind. These hands were further refined, and they allowed the creatures to seize, grasp, pick, and manipulate the tasty gifts of the trees. The long claws of most of their fingers, which now became cumbersome and largely useless, turned into nails, mere relics of their former weapons, only keeping claws on one or two fingers, using it mainly for grooming.

For our distant ancestors swimming through the seas or roam-

ing the surface of the dry land, their head was the main part of their body with which they felt the earth, the things that can be touched. They used their snout to judge the hardness and nature of things. They caught their food with their mouth and pushed things away with their head. The tree-dwellers are now different. Their hands are now a greatly refined apparatus, tailored to catch and to feel. Their fingers have extremely sensitive patches of hairless skin that can be used to judge whether fruits are ripe or not. These hands can be used to bring things to them or cast them away. More than stilts helping the animal escape from the surface of the earth or means of moving its body, the front limbs are now crucial parts of the senses pouring information about the earth, life, and the sky into its world. This sensitivity is further enhanced by the minuscule ridges found all over the skin of these patches, as the irregularities on the surface of any object caressed by the fingers encounter the contrast between the peaks and valleys of these ridges, intensifying the triggering of the nerves found beneath the skin. The doorway to the world of the animal is therefore no longer uniquely its head, but also its sides. The integration of the hands with the other senses is nonetheless an important consequence of this evolution.

The world of the tree-dwellers is fundamentally different than the one of their predecessors living on and in the ground. The obscurity of the lower parts of the forest and of the nighttime, during which they were the most active, made them rely heavily on their sense of smell, touch, or hearing, as they had to track insects and other small moving creatures to feed themselves. Now that their home is the trunks of trees and their roads branches, where the slightest misstep can lead to a deadly fall, the role of the eyes becomes more prominent. The side-facing eyes of the land-dwellers have evolved into forward-facing ones, as depth-perception considerably improved the creature's capacity to judge distances and therefore safely jump from branch to branch, whereas the larger field of vision its ancestor enjoyed became largely obsolete in the heights of the forest, where few predators would be able to stand in ambush and pounce on them. This reflects the status of our ancestors, who found themselves at the top of the hierarchy of life. At the time fearless and confident, they no longer needed to watch their back, wary of dangerous encounters, but rather looked forward, where they wanted to focus their attention. In

this new world, the eyes are paired with the hands to pick up the fruits hanging at a distance on the branches. They guide the hand as the animals seize their prize, but even before that, they allow them to choose which fruit would be worthy of the effort. Their land-roaming fathers who busied themselves during the darkest hours had lost the ability to see the three primary colors that the first conquerors of the dry had discovered, but now that their kind once again occupies the daytime, this ability is soon rediscovered and favored by life. The fruits then shine throughout the forest, with their hue serving as a sign of their ripeness. On the green curtain of leaves of the forest, under the azure sky and above the sooty earth, reddish dots are painted by the trees, accompanied by countless others, using the full palette of nature. Sun-colored bananas, violaceous berries, or crimson apples, all display bright colors to seduce the dwellers of the forest, so that they would be eaten and the seed they contain would be dispersed.

The trees offer an abundance of food, which cannot escape and appears always at the same place. Before, the prey of our more distant forefathers ran away in fear but now the trees compete between themselves so that the fruits of their labor, part of themselves, would be eaten and carried away. The relationship between the animal and the tree, the dweller and its home, is nonetheless not as simple as it may appear. The tree entices the creature with the appeal of its fruits, but as it grasps it, the animal is caught in its web, not one made of branches and lianas but rather of dependency and desire. The hands of our ancestors were shaped by these trees and their gifts. It is them who invited the animals to seize, to collect, and to possess through these new appendices found at the extremities of their front limbs. They could already seize with their mouth, but only momentarily, and with discomfort, whereas they now can hold on to things, preventing others from taking them away. The desire for possession was therefore kindled within them, by the trees themselves, which both gave them hands and the things that they would want to grasp. Doing so, the pillars of the forest soon tied these creatures to them, through the illusion of possession. Thinking that they possess a piece of land and the trees on it, they protect it from intruders. They defend it with their lives, sacrificing their being for the pleasures of the palate provided by the giant plants, not realizing that they are now possessed by their power. Letting the creatures think they possess

the trees, the trees now also possess them, making them disperse their seed and paying for their service with sweet gifts, like children rewarded by a parent. This predicament, far from bringing the creature to a lethargic servitude, invites a further evolution of its kind.

The desire and possessiveness kindled within our ancestors by the trees fan the flames of the war between the members of this branch of life. Conflicts over property and territory soon become omnipresent, as the bountiful gifts of the forest have led to an explosion of the animal population, making their living space crowded and resources scarcer than before. These rivalries must be resolved, either through peace or war, communication or battle. Combat can foster strength, among individuals as well as the group, but a permanent state of all-out war would swiftly deteriorate the bonds between members of a colony, soon leading to a dissolution and then a general weakening of their kind, as isolated and facing coalitions of enemies, they would be easily vanquished. War must be paired with love. Strife must be balanced with affinity, and communication is the most efficient way of solving disputes within a group.

Communication is a very broad term, which includes all the ways by which meaning can be expressed and perceived, such as gestures, sounds, tokens, patterns, or facial expressions. This last element is precisely one that emerges at this point in our bloodline. The hairless portion of the face grows larger, revealing the skin underneath it. By contracting the fine muscles of the face, the animal can display different patterns with this skin, changing according to its emotions. Anger would soon be associated with an exhibition of the teeth, paired with shouts of rage. Attempting to woo a mate or appease an enemy, more delicate contractions and movements would be employed. Meaning can nonetheless emerge naturally, as pure convention, with particular patterns gradually associated with particular emotions, without any inherent association between the contraction of the muscles and a specific feeling. Convention here nonetheless does not necessarily imply learning. Innate facial expressions may have emerged through selection, and be linked with an emotion without prior learning. Smiling appears to be one of these,¹ as it is almost universally shared among the de-

¹See: David Matsumoto and Bob Willingham. "Spontaneous facial ex-

scendants of tree-dwelling monkeys, even when the animal is blind, unable to have learned it from its parents.

The emotionless faces then began to be ignored or neglected, while the most expressive ones caught the attention of their peers, and grew in prestige and power. The inept communicators had fewer mates to choose from, and thus their descendancy was less numerous than those of the entertainers and commanders of the group, who made their will known and caused it to be respected through the convincing power of their face, the thunderous roar of their voice, or the grand gestures of their arms. The ability to communicate therefore grew, embedded in the library of information of their kind. A palette of emotions was encoded into facial expressions, sounds, and gestures, with a core knowledge flowing in their blood, which was soon completed with a learned one. Their world allied the innate and the learned, filled with this new dimension of expression, things that are supported by the earth, as manifestations in the material world taking the form of gestures or sounds, but also existing beyond this material, earthly realm, as worldly objects.

The remarkable expansion of the ability to communicate allowed the strengthening of the bonds between mates, members of a group, or species. Power disputes could now be settled less violently, preserving lives. The considerable increase in stimulation of the animal's brain contributed to its further development, with the most skilled individuals being rewarded with numerous mates and children. Smarter and capable of expressing a wide range of emotions, from the most touching smile to the most terrible frowning, the monkeys are the sons of the trees, shaped by them into these prodigious creatures, which at the time of their emergence represented the apex of life. They translated the play of love and war, affinity and strife, into smiles and roars, embraces and threatening gestures, allowing this play to be unfolded more openly, more directly, by entire groups at every instant. This consolidates the shared nature of their world and allows a significant acceleration of its edification. Built on top of life, this world, sheltered within the networks of nerves of these monkeys, will soon play a considerably larger role in the life of their descendants.

pressions of emotion of congenitally and noncongenitally blind individuals". *Journal of Personality and Social Psychology*, vol. 96, no. 1, 2009, pp. 1–10

Re-flection: The Forest Within Us

If we are blessed with living in a land where forests still have a place beside the concrete jungles, the richness of colors, shapes, and patterns they offer certainly has caught our eyes in the past. Walking in these emerald seas, we enter a secluded space built with living walls, hiding earth and sky, one that is entirely devoted to life, sheltering various of its branches and offering them protection.

Behind the veil of splendid tranquility that the forest offers, this space is also a cocoon that shaped our kind. Our ancestors lived on the pillars of life forming its frame and our bodies bear the marks of their influence. Before they stepped into this emerald sea, they crawled on the ground and were akin to the rodents of the fields, but once they let the trees shape them, they emerged out of it as primates, climbing, swinging, and walking.

Looking at the four long limbs of our body, our arms and legs, each endowed with five fingers or toes, we may see our resemblance to the lemurs and monkeys that have remained in the green cocoons of life. These limbs owe their length to the nature of the trees, steep pillars of wood offering their fruits to animals, as our ancestors were chosen for their ability to climb them and reach the nutritious spheres of nectar growing on them.

Grasping an object with our hands, letting our long, nimble fingers clutch it to prevent its fall to the ground, we may see in this gesture a part of our inheritance from the tree-dwellers, the work of the forest on our body. The trees lured our forefathers with their delicious fruits, and thus did they forsake the earth for them, abandoning their dens in the ground for the branches suspended between the earth and sky, ground and air.

Our long arms and agile fingers nonetheless now also allow us to convey emotions to other beings using our limbs. Taking someone into our arms in a loving embrace, letting our fingers touch his or her flesh and bones, we may remember that such a gesture began with babies hanging on their mother as she climbed trees. This manifestation of love has been taught to our ancestors by the forest, and it is now preserved by us.

Now bringing our hands together and slowly rubbing them against one another, their sensitivity can be noticed. Every ridge

on the skin of our palms and fingers enhances the contact felt by the nerves underneath it. Gently pressing the fingers of one hand on our skin, we can judge how soft is our flesh, how hard our bones are. This exceptional concentration of nerves allowed our forest-dwelling ancestors to determine the ripeness of fruits, and it now serves a considerably wider spectrum of purposes in us, allowing incredibly intricate work.

Our eyes should now be turned toward a mirror, to behold the imprint of the forest life upon our faces. The area including our lips, cheeks, eyes, and eyebrows then indeed began to play a major part in our world. Our emotions became interlaced with the nerves commanding the muscles of the middle of our faces. From a window to the world, the face became a mirror of our feelings, displaying our joy, anger, or sadness, and thus from this time on, a smile proclaimed gladness to all eyes, with only close species understanding it.

The trees themselves were the ones offering us the occasion to refine the means of expressing our emotions, as they fed our ancestors effortlessly and predictably, inviting them to settle on a precise territory and weave bonds. Our forefathers were mercilessly selected for the expressiveness of their arms, fingers, voice, or face, as their bountiful habitat kindled power plays between the members of a group sharing a patch of forest. Uttering a warning shout or putting a smile on our face, we may reflect on the origin of such skills.

Chapter 9

Swinging, Striking, and Rising: Apes

Our forest-dwelling ancestors had ample time to acquaint themselves and be shaped by their habitat, as food was abundant and relatively easy to reach now that they discovered the advantage of long limbs and agile hands. Somewhat relieved of the burden of hunting for prey or escaping omnipresent predators, tasks that occupied a large part of the life of older beings found on our blood-line, these fruit-eaters devoted more time and effort to interact with both the forest and the other individuals belonging to their kind. They leaped from branch to branch, climbed the tallest trunks, and unceasingly explored this life-space around them, this living body that they inhabited, made of trees and countless other beings burned by the fire of life.

Such a life may appear easy, but these creatures are nonetheless still at that time continuously subjected to various pressures. They remain caught in a battle of forces considerably larger than them, and as a result, they must continue to adapt or perish. Even within their own kind, the play of love and war, affinity and strife, more than ever occupies a central part in their existence. They attempt to seduce mates, bond with partners, or cherish their offspring, while they also wage wars against invaders of their territory, combat those who want to subjugate them or deny their authority, and slaughter those who threaten their loved ones. This play of love and war, life and death, therefore once again guides

the evolution of these creatures. Now that the rage of the sky that obliterated the largest living things roaming the earth has been appeased and that the earth bountifully provides for the animals, the will to fight of our forefathers is turned against themselves, their own kind. Competition becomes fierce between individuals and between groups. Strength is now exalted, as the weak is forced to submit, while the strongest reign over the whole.

Pressure is thus exerted by their own kind on themselves, favoring larger bodies, stronger arms that could strike an opponent and crush his bones. The lean monkeys then slowly grow in stature and vigor. This movement of growth of the flesh is nonetheless soon confronted with a serious obstacle, the need for agility to reach the fruits that sustain the fire of their life. A sturdy, heavy body impedes the creature's capacity to leap from branch to branch, stepping onto the thinnest ones to reach the least accessible gifts of the trees. The larger one is, the harder it is to escape the ubiquitous pull of the earth. Two forces are therefore now pressuring the animal, attempting to lead him in different directions, as agility usually implies a modest size, while strength is often linked with a larger stature. Life nonetheless has a prodigious capacity to discover solutions to the most puzzling conundrums. It uses the remarkable play of affinity and strife, first producing countless new unique individuals through the performance of the ritual of love, each one of which representing a random exploration of the realm of the possibilities offered to life, followed by a ruthless selection, a civil-strife that sees the unfit vanishing into oblivion and the pioneer, those who were endowed with new, useful features, offered a large descendance. Out of all these attempts, a way to reconcile the opposing forces was discovered, a way to ally a large stature with an agility allowing the creature to both impose its authority and easily reach the nectarous presents of the pillars of life.

The tree-dwelling creature sees its four limbs getting longer, as it grows in stature. Their muscles are enlarged, especially those on their shoulders and back. The shoulder girdle is the subject of important transformations, allowing the arms to be extended above the head and rotated within a wider angular range. The hands are now large, with long fingers. This slow metamorphosis occurred because it allows the animal to move differently in the trees. The creature no longer relies on brief jumps from branch to branch to navigate inside this sea of leaves and wood but rather

seizes the branches hanging above and pulls itself up, swinging between branches by balancing its body, using the muscles of its arms and back to impart movement upon its heavy mass of flesh and bones, constantly cautious of keeping a proper balance. Swinging demands more strength than leaping, but it allows a massive animal to follow some of the paths of the trees that it would not be able to tread with its feet. Branches are subjected to less stress when they are briefly seized by a swinging inhabitant of the forest rather than jumped upon. Our swinging ancestors, now resembling chimpanzees and other apes, have therefore discovered a way to combine an imposing body size with an ability to navigate the sea of leaves, without needing to return to the soil.

The swinging creatures have completed the movement initiated by the first tree-dwellers, a breaking of the linear nature of their body, with a face that points toward where the living thing is going, and the rest of the body used to power their head and their limbs, whose main purpose is locomotion. Now, these inhabitants of the sea of leaves and branches can sit, orienting their body vertically, toward the heavens, while their head faces the horizon, the body of life caught between earth and sky. Their hands bring objects near their eyes. They use them to peel, smash, scratch, and tear, with each generation exploring the possibilities they offer. The creature's center has shifted, from its head to its upper chest, torn between the importance of its eyes and brain and the one of its hands, with both now indispensable elements of its life. No longer a linear being running on the flat surface of the earth, the ape is a true three-dimensional being, one that can appropriate the fullness of the space opened up by the trees, swinging up and down the canopy, navigating the emerald sea from north to south, east to west, listening to the instincts carved in the innermost parts of its cells and to its senses that pour a torrent of information into its mind, its world. It is at this point that the first sparks of consciousness may have been kindled, as these creatures developed a richer relationship with their own body, constantly using these hands that they saw in front of their eyes, trying to find out what are they capable of. The ego may have arisen as the result of this new embodiment, with a body that is not a seldom-seen part of the creature found behind its eyes, as it is the case with our four-legged ancestors who roamed the earth, but now rather something that is seen almost continuously, with the creature witnessing the

state and appearance of its own body. The self then enters the creature's world, the *it* becomes a *he*, as the *I* emerges out of life.

Full of confidence, the ape reigns over the emerald canopy, allying vigor and agility. He taunts the earth by hanging on thin branches, resisting its downward pull with a few fingers, mocking the ground out of which life arose. Emboldened by such deeds, and ignoring the insignificance of his own self in comparison to the majesty of the forces above and below him, he is now ready to end the sylvan exile of his kind that forced its members to stay away from the ground to take refuge in the heights. Few beasts roaming the earth would now prey on him, and thus he brazenly climbs down or jump on the soil, proclaiming the return of our bloodline on the bare earth, after having been trained and shaped by the trees, diligent servants of life, to reconquer the face of the dry land. Exploiting the versatility of his limbs, the ape continues to swing between the pillars of life in search of their delicious presents, but he also walks upon the ground, with a posture that nonetheless does not resemble the one of his distant ancestors that roamed this land long before his kind emerged. It bears the marks of the life in the trees, the verticality, the orientation toward the heavens that is the one of these light-seeking pillars of life. He is already profoundly accustomed to using his hands to grasp and manipulate rather than as a support for his upper body. He walks in a relatively inadequate manner, that is, one that shows a certain awkwardness and inefficiency, his torso slanted, as if the creature couldn't decide between a vertical or horizontal orientation, torn apart between the sky (that is, where the trees are directed) or the earth. His hands are sometimes in the air, sometimes used as support. This hesitant manner of walking nonetheless fits his needs, as he mainly remains an inhabitant of the canopy. His body is an excellent compromise, a way found by life to balance and exploit the various forces to which the animal is subjected, allowing him to move around the sea of branches and leaves as well as walk upon the face of the earth, swinging between branches, jumping between trees, climbing or walking. As a result of this reconquest of the soil, the world of the ape is thus further enlarged, and he slowly learns to appropriate this new territory.

The time spent in the emerald sea may have brought the creatures closer to the upper realm as they departed from the ground, but this cocoon of leaves and wood nonetheless also largely veiled



Figure 9.1: *A sitting ape.*

the face of the sky to those sheltered inside it. They forgot the coldness of the wet earth during the winter, and the scorching power of the sun's rays during the summer, as they enjoyed being housed by life itself, in the trees, protected from the agitation of the heavens as well as from the coldness of the earth. The alternation of the seasons, which had shaped our four-legged ancestors, became largely ignored by their body. Before, the harshness of the winter of certain parts of the earth decimated the young born during this period, thereby representing a waste of the precious resources of their parents. Those whose bodies showed a tendency to limit pregnancies to the more clement periods of the year thus were at an advantage, and their descendants thrived while the descendence of the winter children vanished.¹ The leafy shelter of our ancestors nonetheless induced a fading away of the breeding season, marking their neglect of the signs of the sky, a deafness to the celestial language. Life thus continues its long work of maturation, slowly taking its independence from the earth and the sky as the heavenly wheels turn, unaware of the fact that it is these two realms, above and below it, that are guiding it toward adulthood, its destiny.

¹The are nonetheless many animals that breed during the winter. This phenomenon is far from a rule, as countless other factors affect the determination of the most appropriate time for breeding.

The azure sky may at this point still be veiled by the green foliage, but now that our ancestors have reconquered the ground, they grow more intimate with the earth, with death. The ground is indeed largely made of the remnants of past living things, the ashes of beings fully consumed by the fire of life. Chunks of flint may represent the most ancient of these, as they are the petrified corpses of minute forms of life, compacted by the conjoint work of the earth and the sky, the pull of the planet and the passing of the years. The sooty layer of dust enveloping the rocky land represents younger remnants of life, whereas the surface of the dry land is littered with withered leaves and dead wood, shed by the forest and abandoned to be reclaimed by the earth, now that they are no longer part of life and have joined the body of death. Sitting on top of this cemetery, this mass grave of his ancestors and distant cousins, our ancestor is now drawn to get more acquainted with these strange objects lying on the ground. His back remains turned toward the heavens, imitating the wooden pillars of life, but his eyes are turned downward, as he manipulates the stones and the dead branches found around him.

The skin of the earth is covered with the debris of life, but this rubbish of the earth and the trees will soon become our ancestor's first treasures. As the ape takes a thin stick into his hand, carrying it around as he searches for insects, he suddenly notices that this dead part of a plant may be able to penetrate holes that are inaccessible to his pudgy fingers, especially the burrows of small crawling creatures. Inserting this stick into their lair and then taking it out, he sees how some of them climbed onto the stick, defending their home against this lifeless intruder. Promptly eating these minuscule beings by putting the stick into his mouth, the ape has discovered something that would profoundly change the life of his descendants: the use of tools. His hands allow him to make use of death to prolong his own life, to employ earthly objects to sustain life. Like the claws of his distant forefathers, these tools represent dead extensions of his living flesh, appendices that are expendable and replaceable, without nerves and thus not sources of pain. Contrary to the claws or the scales, the tool is nonetheless not fashioned by life itself through the play of love and war, reproduction and selection, but rather by the creature's mind and hands. It is not received as an inheritance passed on from generation to generation, but rather a gift of the earth and sometimes

also the fruit of his own labor. Chimpanzees of the present day are indeed known to sharpen sticks to make them more deadly for hunting. They also select and fashion different ones, used in a personal toolkit, with each one of tools having a precise function. Stones are taken into the hand to strike the hard shells of nuts, and leaves are inserted into holes to collect the water inside them. The complexity of the nerve network of the animals now allows him to solve problems, using his mind rather than simply relying on his instincts, product of his library of information. The versatility of the hands thus invites the emergence of more versatility, as the number, shape, and uses of these tools are virtually boundless.

The use of tools, as rudimentary as they may be at this point, marks a turning point in the history of life. The earth, part of death, is appropriated by the animal, shaped according to his needs and his imagination, made to serve him and represent extensions of his body, extensions that would offer him the benefit of specialized limbs and body parts but without the cost, in terms of energy or risk of injury for example. Hitting something with a stone rather than the hand will prevent fractures, in addition to being more efficient. The sticks and stones can be shattered under the blows of the animal, and swiftly replaced by others. Each object found on the ground is a block of raw, earthly matter, waiting to be fashioned into a new tool, a new extension of his flesh, one that would help him satiate his hunger or prevail over enemies. This evolution begins with the discovery of the most obvious, ready-to-use objects such as branches and small stones, but soon it is the whole world around the ape that slowly comes to be seen as a set of things, matter that can be exploited to assist him in his daily tasks. The tree becomes a set of branches, which can be broken by his hands to be shaped into spears or insect-catching rods. The world is no longer a mere space in which the animal is thrown, but also an ore that can be transformed into precious things.

The animal will from now on not only receive the gifts offered by the earth but also take parts of the earth to turn them into parts of his world, fruits of his imagination and labor. He appropriates earthly matter to edify something that remains earthly but also acquires another dimension, a worldly one, based on the creature's mind, which is supported by its convoluted network of nerves. The tool is not part of life. It is as dead as the rest of the earth, but its fashioning by the hands of our ancestors imparted to it a particular

quality, one that is not found in its earthly shape or the nature of its material but rather in the use that can potentially be made of it, a use that cannot be seen when simply looking at the object or touching it with one's fingers. This potential use only appears within the ape's world, within his mind. It is his property, his discovery, invisible to the other creatures. His world is intertwined with the earth, in addition to being supported by it. Creating new tools, he edifies his world as he shapes the earth. The purely worldly, imaginary tool, not incarnated into an earthly object, is nonexistent and therefore useless. The block of earthly matter, on the other hand, is equally useless without the worldly knowledge of the use that can be made of it. The talent of our ancestor, his remarkable gift, is his ability to marry earth and world, matter and mind, to overcome the challenges that he encounters while the fire of life burns within him.

As the ape is capable of learning, the knowledge discovered by one individual can then spread across the members of his kind. Their world is not only an individual construction but something that can be shared with others. They can inhabit common parts of this world, handing over what is found inside it to their neighbors. The utensils created by a master can be offered to disciples, passed on from hand to hand, but without the worldly knowledge of its use, it is simply a scrap of the earth, something indistinguishable from the rest of the great body of matter upon which they sit. Only when the worldly knowledge of its purpose and handling is communicated to the one who received the earthly object will this object cease to be a scrap of the earth and become a tool, part of his world. This world, supported by the earthly, living networks of nerves of each one of its dwellers, can thus outlive them. Like a precious heirloom handed over from generation to generation, the discoveries of the fathers are transmitted to the sons. This world therefore grows and is continuously refined, adapted to the needs of the present. This process, at this point, nonetheless remains largely unconscious, and the species is still ruled by the principles directing life as a whole, such as the play of love and war, reproduction and selection. The ape is then the apex of life, an apex that is fully submitted to the whole that life forms. He has no will to oppose the course of nature, and no conscious desires that transcend the need for survival and the passing on of the inheritance embedded at the heart of each one of his cells. He remains ruled

by his instincts, favoring the transmission of his library of information through mating over the communication of his knowledge of the earth and life, as he is blind to his own nature, and to his place in the tree of life.

The changes in the creature's world are nonetheless extremely profound, and its life is deeply affected by them. They are not only limited to the discovery of tool-use but also concern the relationship between the inhabitants of this world. The hands of the ape can wield a weapon and fashion utensils, but even when they are not manipulating earthly things, they can be used to edify their world, using signs. The range of what can be expressed by the hands is indeed larger than the one of the face. Waving his arms up and down, moving his fingers in various manners, the ape can embody ideas that are purely worldly, transcending the earth and the sky, matter and space-time, using his living body to share knowledge and opinions, things that belong to his world. The physical body is used to represent metaphysical things, with both being inextricably intertwined with one another.

Like facial expressions, the most fundamental body language probably emerged as instincts, inscribed in the library of information of individuals. This body language then spread because of the advantage that it provided, rendering those using it more efficient when struggling to sustain their community or wage wars against others. The ape is at birth thrown into a world that already contains signs, things of the world that bear meaning, and often represent a way to cut out the continuum formed by the earth, life, and the sky into discontinuous things that can be grasped and manipulated by the mind, including using his hands or face to refer to these things while communicating with others, beings found on the part of the earth around him. These living things cannot directly visit the world of another being. Interactions and communication can only occur on the earth, using the senses as interfaces to guide a flow of information from world to world, being to being. These channels, where things of the world flow from mind to mind by passing through the earth, emerge naturally, through trial and error, because those mastering these skills of interaction are more efficient participants of the play of love and war, affinity and strife. Their expressions of affection and anger, tenderness and violence, strengthen the whole that the members of their family, of their tribe, of their kind forms. Unaware of the depths of his existence,

and of the potential that is offered to him by life itself, the ape slowly learns, discovers, and passes on the content of his world to those around him, those who will succeed him.

The world is nonetheless not the only part of the creation that changes. The work of the skies continues with the passing of the years and millennia, with the earth endlessly revolving around the sun, the gilded orb turning around the center of our galaxy, and the milky way pursuing its wandering in the depths of space. Life as a whole is subjected to the whims of the heavens, especially the parts of life that are turned toward them, the emerald beings impassively collecting the envoys of the sun and harnessing their power. At this point in the story of life on earth, the wrath of the celestial forces is once again kindled, following a long period of tranquility that favored the growth of life. It may have been manifested by an intensification of the heavenly brilliance, a diminution of the libations of the clouds watering the face of the dry land, or a combination of more subtle changes of balance between the forces of nature. No matter the cause, which is uncertain, the effect is nonetheless clear. Holes now appear in the magnificent blanket of wood and leaves covering most of the dry land, holes that grow larger and larger each year. Many parts of the dry land are soon inhospitable to the trees, most of which cannot withstand intense heat and demand to be watered profusely and regularly. Dry islands now emerge in the emerald sea of leaves and wood, patches of land where only the humblest light-workers can sustain themselves, satisfied with meager droplets of dew brought onto them by the chilling breeze of the night or rare libations coming from the heavens. Life adapts to overcome every challenge, and the fall of one branch of the tree of life allows another to grow in its place. Where the tall trees vanish, the grasses flourish. Forests give place to vast plains.

The apes are soon confronted with this transformation of the face of the earth. As their number grows and they search for new forests that could become new homes, they are forced to go through the grassy plains, the dry islands, to reach new parts of the emerald sea. Their posture during these journeys on the naked parts of the land is rather awkward and uncomfortable. They hesitantly walk on two or four limbs, their chest slanted. Their forces are spent rapidly and inefficiently during these peregrinations. Their bodies are simply not made for this. They have evolved to swing between



Figure 9.2: *A standing ape.*

branches, not trek through grasslands. One theory, impossible to verify but nonetheless plausible,² advances the idea that the presence of tall grasses in these savannas, steppes, or prairies would have forced the animal, whose height is considerably smaller than ours, to try to stand upward on his two feet to be able to look above these grasses, searching for a way to go. His skeleton would only have allowed brief moments of vertical posture, but no matter the exact cause, a trend then began. Those among their kind who showed a particular ability to stand upward began to be rewarded by nature with a longer life and more numerous descendants. This trend is nonetheless only at its beginning.

²This theory is called the “Savannah hypothesis.” It has been largely accepted for decades, but has more recently been the target of numerous critics. For a critical view of this theory, see: James Shreeve. “Sunset on the Savanna”. *Discover Magazine*, Jan. 1996, or: M. Domínguez-Rodrigo. “Is the “Savanna Hypothesis” a Dead Concept for Explaining the Emergence of the Earliest Hominins?” *Current Anthropology*, vol. 55, no. 1, 2014, pp. 59–81

Re-flection: The Ape Within Us

Long was the sojourn of our mothers and fathers in the sea of amber wood and emerald leaves, and deep was the mark it left on their bodies, transforming their nature, shaping their flesh. Fed by the fruits of the trees suspended in the air, our parents stayed in close contact with them, and as they embraced the trunks with their arms, their bodies began to be turned toward the sky.

Following the guidance of the wooden pillars, our ancestors turned away from the horizon, and they were led to discover the world seen with their bodies parallel to the trunks, pointing upward. The abundant food and the strife between individuals induced a considerable increase in their stature, and the weakness of the branches on which the fruits were found forced them to extend this reorientation.

Our ape-like ancestor not only turned his body upward as he climbed the trunks of the trees, but also maintained such a posture as he ventured on the thick branches to seize his sustenance. Rotating our arms above our shoulders, we make use of one of his remarkable innovations, as this movement allowed him to swing between branches with his arms rather than to jump on them.

Pulling ourselves up with the strength of our upper body, we may feel the difficulty of resisting the earth, but we can also appreciate the wideness of the reach of our arms, which have been shaped by branches. The very size of our hands and the length of our fingers are still well adapted to seize the wooden limbs, even though we no longer have the strength that allowed our ancestors to effortlessly swing between them.

The advantages of the vertical posture of the torso were taught to our ancestors by the trees, but when they descended from these pillars of life to reconquer the ground, their bodies retained it. They sat on the forest floor as we sit now, and this left their hands free, searching for things to do. Without food ready to be seized on the ground, they grasped what lain there: dead branches, leaves, or stones.

Sitting on the floor and taking objects found around us, we may ponder their nature, the use we make of them. These things of our world were built by our hands, for specific purposes, after their

discovery by one of us, and we should remember that this work of edification of our world began with apes on the forest floor. They, like we are doing now, grasped parts of the earth and swung their arms, moved their fingers, to appropriate them, and these things became extensions of their bodies, allowing them to gain power over the earth, life, and the sky.

The hands shaped by the sea of wood and leaves are an ideal tool, as they allow the creation of new tools. They rub, peel, strike, crush, tear apart, or join together, opening up an infinite number of possibilities. Looking at the objects surrounding us, we may reflect on how we turned the earth into things of the world, and on the difference between the thing and the material it is made of, what is the contribution of man to it.

Our hands remain our greatest tool and their versatility allows them to do more than shape the earth into things. The hands are instruments that can bear things of the world as well as those of the earth, including signs, and as we wave our arms and hands, the signification of our gestures, linked with our world, becomes apparent. Arms, hands, and fingers can now express worldly concepts, as well as our voice, or a pen with a sheet of paper, and this has been made possible by the liberation of our upper limbs from the necessity of supporting the body.

The idleness of our hands as we sit upon the ground is the driving force of the edification of our world, and it comes paired with the one of the mind, occurring when one has food in abundance and is safe from harm. Only one who is free, available, unoccupied, can find the time to explore or discover new things for his kind, and as we meditate, sitting on the earth, we may wonder what could we do with our hands and the mind wielding them?

Chapter 10

Standing Up: From Ape to Early Man

After having been formed like a piece of clay and trained by the forest while the face of the earth was being reshaped by the work of the skies for countless years, our ancestors now finally emerge out of the emerald cocoon. They find themselves with more strength, facing the earth, life, and the sky. They now have a more acute perception of their surroundings, a more finely built world, and a more versatile intelligence. As the forests give way to savannas and grasslands, our forefathers are pushed away from their home by the forest themselves, whose weakening body now struggles to feed a growing population of apes. These creatures are nonetheless now far more capable of overcoming the obstacles posed by a relatively rapidly changing land, with some branches of the tree of life being trimmed by the sky above and the earth below while others are nurtured by the same forces. They venture in groups out of the leafy shelter that they saw as their home, walking on the bare earth, using their hands to occasionally support their slanted torso. As they leave the sea of leaves and wood behind, the veil covering the heavens is now lifted up, revealing to the creature the majesty of the skies. They are blinded by the showers of light poured onto the earth by the incandescent orb running daily throughout the celestial vault, and they begin to fear the nights, when they are equally blinded by the darkness reigning over the creation, leaving them exposed to other hunting creatures or the cold wetness of the

tears of the clouds. Weary of exposure, they keep moving, walking long distances in search of substitutes for the forests, places that could become new homes to them.

In the open land, where the body of life is nothing but a thin layer coating the face of the earth, swept by the winds and parched by the resplendence of the sun, the ape finds himself threatened. Fierce predators such as saber-toothed cats have already made many of the plains their hunting ground. Only tightly knitted groups of apes would have any chance of survival against such creatures, and as the weakest, least reactive, and least social apes were trimmed from the tree of life, either by predators, by exposure to the rage of the skies, or an inability to find lower forms of life that would sustain their bodies, their kind slowly grew more accustomed to the open land, and more capable of fighting against the forces manifesting themselves in it. As their descendance grew more numerous, they spread across the face of the dry land, as each new generation searched for virgin lands, where competition would not be fierce, and the fruits of the earth and life would abound. Their lives nonetheless became paced by long journeys across the balding face of the earth, seeking rivers whose flow would quench their thirst, fruit trees that would satiate their hunger, or game that would satisfy their craving for flesh. Many are unable to reach these sources of life in time and thus die on the way, their bodies then sustaining lower forms of life as their bones are patiently reclaimed by the earth. The unforgiving nature of their life thus favors those able to walk through the steppes and pass over mountains rapidly, without wasting their strengths.

Those walking using their four limbs are soon left behind by their kind, unable to remain watchful for the ravening beasts roaming the plains due to their posture, with their line of sight too low to notice the dangers around. The limping ones are later subjected to the same treatment by life, as they are slower than those whose walk is smooth and whose body stands erect, and they require more food to travel the same distances. The apes therefore begin to lose their slanted posture. The individuals whose skeleton is more adapted to an erect posture are more successful at giving life to children, leading to a spread of this advantage among their kind. The creature is patiently shaped by the life in the plains, where it is no longer protected by a bed of leaves and wood but rather must face the scalding sun and the rocky earth each day of its



Figure 10.1: *From ape to early man.*

life. Walking, and then running instead of swinging and jumping, it turns into what begins to look like a human being. The fierce competition among its kind and the necessity to fight predators and hunt prey has led the standing one to grow taller than his ancestors. His arms have grown shorter, more adapted to running, throwing, or wielding pieces of wood while standing upward. His mouth is smaller and less prominent, rendering the head easier to balance on the neck. This nonetheless does not imply the absence of any force opposing this rising up. The changes operated on the hip to allow a comfortable standing posture indeed implied more difficulty to give birth to children, often resulting in the death of either mother and child, a phenomenon that perdures to this day.¹ This inconvenience nonetheless does not outweigh the advantages of this posture, and this is why our ancestors thrived, nonetheless.

This series of changes, forced upon their kind by the work of the skies, leads our forefathers to cease to turn themselves downward, toward the earth. The heavens take away the blanket of leaves in which the animal found security and stability, blind to the relentless flow of the skies. They make his leafy vestment wither and scatter these leaves to the winds, leaving him naked, exposed, under the million bright eyes covering the celestial vault.

¹This is technically known as the “obstetrical dilemma.”

This exposure is paired with an unveiling of the horizon, the surface separating and joining earth and sky, with the spectacle of the magnificent rising and setting of the sun finally offered to the eyes of the one walking the plains. Plunged into the open country, where nothing stands between him and the celestial heights, he stands up straight, his whole body pointing toward this unfathomable expanse. His eyes briefly behold the majesty of the heavens, as he occasionally turns his head upward, but his natural posture, reflecting what is most important in his eyes, is the world below, or more exactly, the world in between, the surface caught between earth and sky, the middle realm of which he is part. The withering of the forests and the opening of the land resulting from it considerably broadens the horizon of his world. His standing posture then furthers this movement, enlarging the range of his territory, the part of the earth that he explores and appropriates. His world is no longer limited to a few trees that sustained him with their fruits, enclosed in a fortress of wood and leaves. It is now vast grasslands, mountains and valleys, shores and seas, with the entire earth made his possession through the power of his eyes and his feet, brought together as the scattered tribes reclaim their dominion over the face of the earth, which was lost to a few large and ferocious beasts.

The work of the skies, by causing the forests to wither away, therefore brings our ancestor not only closer to the heavens by raising him up, changing him from a slumped creature to one proudly standing up, ready to face the forces of nature without fear, but also helps him discover the vastness of the earth, and assert his dominance over it. The standing creature appears empowered, by the heavens themselves. It is encouraged to spread over the earth, able to withstand the whims of the skies and subject other forms of life to its authority. The body of life grew lean, covering a smaller part of the dry land, but through this event, a particular branch of life grew higher and stronger than any other before. Like an arrow shot out of the shadows of the forests, these standing creatures represent a revenge of life, the middle realm fighting back, counterbalancing its withering by pouring its entire resources into a single cohort, a single weapon that would represent the best chance of life to reconquer the territories lost following what appeared as a heavenly aggression.

The upward being walks on the grassland, runs through the

deserts, swims through the lakes and rivers, jumps over the chasms, wounds of the earth. He experiences the cold winds of the winter blowing on the plains, robbing his body of its warmth, and his skin is scorched by the celestial fire during the summer. His new orientation also contributes to helping him withstand the assaults of the sun, as his verticality reduces the surface of his body hit by the sun when it is at its zenith, only striking his head and shoulders, while his body heat naturally flows upward, cooling down his skin, far more than before. His life, spent naked running across the plains or dwelling in scattered woodlands, is hard but filled with an extremely large range of experiences. The environment demands much of him, and as a result, only the fittest of his kind survive its trials. With the weight of his head now well distributed on the neck as he stands, his brain can grow larger, without impeding his movements. Intelligence is rewarded by a greater descendence, and therefore the intellect of his kind becomes more astute. One of the most important consequences of the rising up of our ancestors nonetheless has yet to be mentioned: the freeing of the hands that comes as a result of only using the legs to move on the earth.

As the front of the four-legged creatures became the upper part of the two-legged ones, the hands lost the last traces of their original, ancestral use, which was to elevate the front of the body above the surface of the earth, reducing contact with it to a minimum because it is easier to move through the air than on or in the soil. Other branches of life such as birds also began to stand on their back limbs and found a new use for the front ones, which became the wings allowing them to conquer the lower skies. In the forests, our ancestors were already used to swing, seize, and manipulate, but now, in the plains, with their bodies standing straight, their hands can be used to carry. The things around them can not only be used, they can also be transported over long distances. Wandering around the open land, migrating according to the rotation of the heavenly wheels, the passing of the seasons, the standing one no longer has to abandon the primitive tools that he either rudimentarily fashioned from branches or bones, the plants that he foraged or the meat he caught. The most important things can be carried in his hands as he walks or runs through the grasslands in search of a more clement climate, a less crowded land, or more abundant forms of life upon which he could prey.

The standing being is therefore invited by his own nature to

go further on the way of possession, following the ape whose hand first allowed the seizing of the fruits, allowed not to let go of the things having an earthly, material nature. He can now not only seize, but also take with him, and bring things from remote parts of his known world to any other place. Other creatures can carry things with their mouths, but only the smallest ones can take away objects almost as large as their own body, being less affected by the pull of the earth. Among the large inhabitants of the dry land, only he can drag large pieces of wood or stones across the plains. Only he can feed himself or drink while both carrying something and walking on the earth. Only he can pick up, carry, and throw stones to frighten or crush prey and foes. This versatility and this facility with which he can handle things may have then further kindled his desire for earthly possessions, gathering more than he could consume, hoarding more than he needs, inflating his nascent ego as he faces other members of his group, or perhaps easing the angst of having experienced famine or violence, the rage of the skies and the one of his fellows.

The hands of the standing one are weapons of love and war. They can wield sharpened sticks, thrown at the wild oxen migrating through the plains, and they can gently stroke the hair of a lover. They can be used to keep men apart from one's body, as they can bring closer in a tender embrace. They are vessels into which the emotions of the one controlling them can be poured, but more than this, they are also interfaces through which the earth, life, and the sky are put into contact with man's world, where mind encounters matter. His thoughts, his imagination, can be translated into deeds affecting the creation and into things made of earth. They allow him to be more than a passive dweller of his world, ruled by his instincts, but also a creator, someone who edifies the world he shares with all other branches of the tree of life, even if at this stage this capacity is only nascent. The world that he inhabits is nonetheless far from lonely. The loners have been winnowed from his kind by life itself, as these were easy prey for the fangs of beasts, the chasms in the earth, or the furor of the skies. More than ever, he stays with his own and weaves ties with them.

Packs slowly evolve into tribes, which share more than a mere part of the earth. They work together to hunt, using shouts and their hands to coordinate their efforts, driving mammoths to fall



Figure 10.2: *An early man.*

to their death from cliffs, or isolating the weakest animals to pierce their skin with wooden spears when they witness large migrations. Deeply aware of the dangers of the savannas and the grasslands, they seek refuge inside the body of the earth, the dark caves on the side of cliffs and mountains, inside which they find shelter from bears, saber-toothed cats, and other ferocious parts of life, including rivals belonging to their own kind, as well as from the rains watering the grasses and the chilling winds stealing their strengths when the sun has retreated beyond the horizon. The tree-dwelling ancestors of the standing one were enfolded by life during their entire lives, sheltered by living trees with the canopy as their roof and a carpet of withered leaves as their floor. He now faces the greatness and power of the skies, its ever-moving flow that burns and chills, wets and dries, brings and takes away, and striving daily against the heavens, often overwhelmed and tired of this Sisyphean battle, he sees the earth as an ally, the only force of nature that can help him withstand the anger from above, the one that already took his ancestral home, the luxuriant forests that once covered the earth.

The body of the earth already was the home of his distant forefathers, the four-legged creatures that dug dens deep into the soil. It now once again houses their descendants, but the bond that he begins to weave with the earth is not limited to this sheltering.

Endowed with his agile hands, allowing him to manipulate the earth to a degree never seen before, he experiments and explores its nature. The wooden sticks that he uses as tools, former parts of life that now have joined back the body of death, are soon found to be an inferior material for parts of these tools. The corpses of past trees indeed represent a good compromise between hardness and plasticity, as they can be shaped with minimal effort but offer enough resistance to be used to break bones, pierce skin, and cut flesh. The standing ones nonetheless soon discover that the body of the earth, the rocks found beneath the sooty soil formed by the decomposed cadavers of past living things, can also be shaped into tools by his hands. These gifts of the earth demand more skills to be shaped, but the rewards of such work justify the effort.

The hand of the standing ones cannot by itself shape rocks. The compact and indurated crust of the earth can only be broken down by the only things (at this point) as robust as it is: itself. The standing one, throwing rocks in the air and letting the pull of the earth bring them back to the whole that the planet forms, witnesses how some of them are broken to pieces when they encounter others on their way down. Among the fragments produced by these collisions, some are sharp and pointy. He seizes these bits of earth, touching their edges, which cut through the skin of his fingers, revealing drops of the crimson liquid of life. Applying this sharp-edged splinter upon the flesh of a catch, it pierces its skin with few efforts, demonstrating the superiority of the gifts of the earth over those of life for this precise task. Stone tools are born, as he and his kind learn to break apart the earth to turn pieces of it into parts of his world, tools that help them to survive and prevail in their struggle against other parts of life. The two facets of death are then allied by their hands, the wooden gifts of dead trees and earthly stones are brought together to form rudimentary axes and spears with pointy stones at their tip. The earth is nonetheless both one and manifold, and its face is covered with a wide assortment of stones, displaying all the colors of a rainbow and exhibiting a great diversity of hardness, sharpness, and texture. One type of them, in particular, would prove to be invaluable for the fashioning of tools: flint.

Flint is abundant over the face of the earth. Its crystalline structure, that is, the fact that it is made with regularly ordered bits of matter, gives it the peculiarity of breaking into long, sharp

flakes when hit against another stone. This peculiarity is nonetheless not immediately apparent, as blocks of flint mostly appear as large chunks with round edges, patiently eroded by the work of the skies and the flow of the rains permeating the soil. Only when broken is its sharpness and true color revealed. Mastering the way flints break demands a long practice, but once acquired, these skills can then be taught to others, and the standing ones are now endowed with a sufficiently acute mind for this task. Razor-sharp blades can then be produced in great quantities in a single day, cutting through skin and flesh, allowing rapid butchering and the creation of redoubtable weapons. This precise kind of stone will be the raw material of choice of our ancestors, for a considerably long period, and unbeknownst to them, this precious gift of the earth also represents a present from our distant forefathers, as flint blocks are formed with the petrified remains of our marine predecessors, the silica found in the spikes of sponges and the minute forms of life that filled the ocean, when life was in its infancy. Reclaimed by the earth, compressed and hardened by the work of time, these remnants of our most distant ancestors are now helping their remote descendants to overcome the trials of the life in the plains. They are a benevolent hand raising the dwellers of the plains out of their impotency. These bodies of their forefathers will now be turned into new extensions of their bodies, knives and axes that would allow them to reign supreme over other forms of life. Life is thus allied with the earth to allow what can now be called the early man to resist the assaults of the skies, countering their work of destruction of the forests that took away the home of his ancestors and their main means of subsistence.

The life of the early men nonetheless remains hard. They continue to be winnowed by the skies, while the competition between them increases together with their number. Muscles are now not as favored by life as a sharp mind, and therefore early men become more intelligent as the blunt has fewer descendants than the sharp. Once again, an event that may at first have appeared as an aggression originating from the celestial forces nonetheless will prove to be a great blessing in disguise, as the clearing of the plains were, guiding the evolution of mankind, toward greater adaptability, a finer intellect, and ultimately a more sophisticated world. This event is man's first wielding of the power of fire.

Fire is as old as the earth and the skies, and it comes onto the

face of the earth from both above and below. The planet at times pours out its fiery blood out of its wounds, spilling molten magma that ignites the grasses and the trees, consuming the body of life and reclaiming it, letting the heavens have their share in the form of smoke and vapors rising to join the clouds while the ashes seep deep into the soil. The charcoal clouds weeping over the dry land and the seas nonetheless represent the main source of fire kindling the middle realm, setting it ablaze while flooding it with rain, both fanning flames and quenching them. The thunderous rage of the lower skies strikes the face of the land and the life covering it almost constantly, in some part of the globe. Lightning bolts find their way through the air, creating channels through which the content of the heavenly vaults of light and tension can flow, like a torrent of energy that melts or consumes all that it touches. Once these torrents run dry, in an instant, they leave behind flames fanned by the winds, which grow in size, devouring the woodlands. These same lightning strikes from the sky contributed to the kindling of the first sparks of life, as they transformed elements into what would become the building blocks of this wondrous chain reaction, but now, they extinguish life, as animals are forced to flee from their sylvan homes in fear as the fire spreads from tree to tree. Animals therefore very early became familiar with the dangers of the flames, this mysterious force that transformed the living into ashes with flashes of light shining like the sun even during the darkest hours of the night. They learned to fear this form of fire from heaven, these bits of sun running through the vegetation, only stopping when starved of the bodies of living or formerly living things, or flooded in water. The early man nonetheless soon learns to dominate his fear and tame this ravening and feverish beast of light, and the event of this taming would change his own nature.

When the fire from the clouds struck a tree and set it ablaze as the freezing winds robbed the early man of his precious heat, he found solace in proximity with the flames, bits of the sun that fell to the earth, warming his hands numbed by the icy breath of the skies flowing through the dry land. Witnessing with anxiety and sadness its radiance and warmth fading away as the trunk turned into ashes, he began to feed this beast of light and heat, prolonging this mysterious celestial manifestation occurring on the earth. He then discovered that the inflamed branches could be carried away

without danger, brought near the entrance of the cave he transformed into his home. Fanned and fed, the embers of the branch are then turned into a hearth, filling up the moist cave with warmth and bathing its walls with soft, fickle light, contrasting with the moving shadows of the men surrounding the luminous beast. The mystical power of this discovery seduces the hearts of men and enslaves their mind. They will work to serve this beast, feeding it continuously with the corpses of trees found around their camp, protecting it from the winds and the rains, and the covetousness of other men, who do not partake of the blessings of this fire that rained down from the heavens.

By chance or curiosity, meat was one day left near the flames and after it was cooked by the crimson beast of light, it was found to be tastier and easier to digest. Man discovered cooking, increasing the prestige and usefulness of the fire. Children of the first hearth would soon be born, by luring the flames onto new branches, carried away to new camps, and soon its descendants grew as numerous as the families of men. The body of fire consuming dead wood, life turned into death, grew and spread over the dry land. Becoming a vital element of man's life, it is at this point fiercely defended and tended to with great care, as the survival of the tribe might depend on it if its members live in the colder parts of the dry land. The caring of the fire demanded teamwork and unity between men, favoring the strengthening of the bonds between those forming a family or a tribe. The men wielding the power of the fire from heaven here on earth were protected by it from the torments of the clouds and the winds, and as they cooked what they ingested, they also purified their food, killing the countless minuscule lifeforms that lived as parasites inside their meat or vegetables. As a result of this purification by fire, their health improved, and they soon outnumbered those who were incapable of taming the power of fire. Grilling or roasting their meat also allowed them to extract more nutrients from it, as the blaze broke down the hardest bonds between the substances composing it, facilitating their absorption by the body.

What began as another assault from the heavens once again proved to bring blessings to our ancestors, as the fire from above now allowed them to resist the rage of the lower skies and to break down the flesh of formerly living things more efficiently than ever before, offering them more energy. As a result of this increase in

the flow of nutrients entering their body, the size of their head slowly grows larger, and the traits of their faces become more and more similar to our own and less ape-like. Here comes the point when the pace of the transformations of the body of our ancestors begins to become relatively insignificant compared to the dramatic evolution of his world. These early men are now not only shaped by the earth and the sky, but also considerably influenced by what is thought, learned, and taught by other members of their kind. The hands of man begin to shape more and more parts of the earth, as he makes tools, move rocks and branches to make shelters. These hands begin to shape the landscapes of the dry land, and the world of men grows in size and refinement. The amount of knowledge and skills that is shared through learning rather than instinct, embedded in their library of information, increases considerably, as the art of flint flaking, hunting, butchering, and cooking is handed over from father to son, from neighbor to neighbor, forming a world that rests upon the mind of those belonging to their kind, only partially visible on the earth when it is used to influence it. The final step in the history of our evolution now has come.

Re-flection: As We Stand

Life guided the slow ascent of our ancestors from the depths of the sea onto the dry land, and it then sheltered them under the emerald canopy of the forests, closer to the heavens. It began to turn their body upward, pointing out toward the sky, imitating the posture of the trees, before they finally sat down upon the ground, as the heavens slowly destroyed their wooden home.

Forced to leave the seclusion of the forest, they discovered the plains, the moors, and the grasslands, and the exhausting journeys in search of food and shelter put new pressures on their kind. The exposure to the dry land and the windy sky shaped their bodies, as the forest did before, and thus they were led to stand upward, themselves becoming pillars of life standing upon the earth, as if they paid homage to the disappearing trees that made them who they were and taught them.

As we rise after sitting on the floor, pushing our body upward with the muscles of our legs, we may notice how well our body is adapted to such a posture, which can be kept with few efforts. From our neck to our ankles, our entire skeleton is like a tower of bones in perfect equilibrium, and the pull of the earth is, while we live, powerless to take it down, as it obstinately points upward.

This posture allows us to elevate ourselves above the grasses of the plains obstructing our view, and it minimizes the surface of our body in contact with the earth, reduced to the soles of our feet. Proud and empowered by our stance, we declare ourselves as much the sons of the heavens as those of the earth, and as we walk and run over the surface separating the two, we may experience the duality of our nature.

Our upright posture led to a definite abandon of the use of our hands to move across the earth, and now, our legs alone assume this role, leaving our hands free, even when we walk the earth. Our hands and arms can carry things around as we travel through the land, instruments of life or death, and we can hold or throw away, pull or push, strike or caress, both things of the earth and living beings.

Combining the use of our legs to roam the land and the use of hands to shape earth, life, and world, our ancestors were offered

a considerable advantage over all the other creatures populating land and seas. Even without fur, horns, or wings, man could indeed prevail over the three realms using his mind, as he by himself built the tools that his body lacked, shaping them from branches of wood or blocks of stone, and used them to launch attacks against other branches of life, to oppose the sky, or to pillage the earth.

Our hands would nonetheless be largely useless without the power of the mind pulling their strings, and even though the emergence of man may be considered to begin with his rising up from the ground, it is the edification of his world that defines him, a world propagated through time through learning. Striking blocks of flint together, we may experience the learning process of our distant fathers, observing the sharp flakes and attempting to turn them into blades that could be used to cut flesh.

The perfecting of our body nonetheless did not end with the rising of man, as he left the woodlands. The gift of the fire from heaven, domesticated by our fathers, led us to grow dependent on it for warmth and food, as it allowed us to resist the night and the winter and helped us break down the hardest food. We are thus now durably tied to this fire, as our stomach can now only difficultly digest uncooked meat, and our subservience to this mysterious phenomenon may be seen as a symbol of our dependency on our world. Cooking food inedible raw, we may meditate on our reliance upon fire and other elements of our environment.

The larger our world is, the more difficult it may be for us to peer at what lies beyond its frontiers, but no matter how high we ascend, how exalted is the point where we stand, or how broad is our horizon, our body remains as it was shaped by the earth and the sky, made to fit a lifestyle already long gone. We will not see major changes to our kind in our lifetime, but the play of love and war continues unabated, and one day our children may transcend our present horizon, rising further up than anyone before.

Chapter 11

Building with Hands and Words: Man

Wielding fire and stone with its hands, the walking creature extends its dominion, now covering the entire tree of life. Our ancestors soon reign supreme over the dry land and even venture into the lakes and the seas, with only the forces of the earth and the sky limiting their ascent. The celestial forces calm their ambitions with sandstorms and blizzards, floods and droughts, while the earth reminds them of their feebleness and ephemeral nature with earthquakes, volcanoes, and landslides. Watching these naked creatures roaming the plains and dwelling in dark caves on the flanks of cliffs and mountains, one may not be impressed by their appearance. They indeed have no horns with which they could gore their rivals and foes, no sharp claws with which they could spill the blood of their prey. Their teeth are inoffensive, and their stature is modest when compared to many of the beasts running through the grasslands. They have no fur to protect them from the chilling winds of the night, nor hoofs to preserve the sole of their feet from being lacerated by the rocks upon which they must tread. And yet, despite this apparent frailty and helplessness, they now dominate all the other living things.

The gift that man received, which outweighs those of all the other creatures, is his capacity to learn, which is considerably more developed than in any other branch of the tree of life. What he has not been given by life itself, he invents and builds. He observes

the world around him, made of countless living beings that greatly differ from him. He beholds the earth and the sky, interpreting the signs pervading them. Reigning over the living, he nonetheless knows that his kind is surpassed in many areas by other branches of life, and that they can teach him to overcome his innate weaknesses. What the other animals have been given by nature, he must discover and build by himself, and it is these trials that allow him to raise himself above the rest of life. As noticed at the dawn of our history by Plutarch:

We have become the pupils [of animals] in the greatest arts: of the spider in weaving and mending, of the swallow in building, of the songbirds, the swan and the nightingale, in singing, by our imitation of them.¹

The greatest gift bestowed by life onto man is his versatility, his plasticity, not only the one of his mind but also the one of his flesh. His legs are not the strongest, the fastest, or the longest of the creation, but they represent an excellent compromise, allowing him to walk, run, and jump on all kinds of terrains, no matter whether it rains or snows, whether the ground is sleek or filled with holes. His hands are even more versatile, allowing him to shape the earth according to his will, to nurture life and to extinguish it, as he plunges them into the depths and extends them toward the heights. Man nonetheless not only imitates other forms of life, he also follows their lead.

Man may think of himself as an elevated being, who can look down on other creatures, but he should still keep in mind the fact that these creatures not only taught him many of his arts, they also guided him toward the part of the dry land he now calls his fatherland. Dependent on these lesser forms of life for his sustenance, he had to wait until they were sufficiently abundant before he could invade and dwell in new parts of the earth. Up until the present day, the lands where no plants can take root, and no animal can

¹From: Daniel W. Graham. *The Texts of Early Greek Philosophy: The Complete Fragments and Selected Testimonies of the Major Presocratics. Part 2*. Cambridge UP, 2010. Page 575. Original Greek: Γελοίοι δ' ἴσως ἐσμέν ἐπὶ τῷ μαθάνειν τὰ ζῶα σεμνύνοντες ὧν μαθητὰς ἐν τοῖς μεγίστοις γεγονότας ἡμᾶς • ἀράχνης ἐν υφαντικῇ καὶ ἀκεστικῇ, χελιδόνος ἐν οἰκοδομίᾳ, καὶ τῶν λιγυρῶν κύκνου καὶ ἀηδόνης ἐν ᾧ κατὰ μίμησιν," from: Graham, *The Texts of Early Greek Philosophy. Part 2*. Page 574.

graze, such as the poles and the largest deserts, are devoid of cities and large settlements. First comes the water, then the plants, then the smaller animals, and only then can man follow their lead, and this is what he did once his body had matured enough, once the earth, life, and the sky had completed the fashioning of his flesh, made versatile enough to adapt to almost any place where other forms of life already took roots.

Families grew in numbers as the heavenly wheels continued their endless revolutions, and as the land became unable to feed this profusion of descendants, groups parted ways from their parents, settling in their vicinity. In minute increments, the branch of the tree of life we call man itself was branched into numerous shoots, each occupying a portion of the dry land. Like the buds of the early spring, they sprouted year after year and furthered their branching, becoming an increasingly convoluted genealogical web. Each tribe, each people, inhabited a unique world, with its own landscapes, its own fauna and flora, and even its own sky, where different shades were displayed and the celestial forces expressed themselves with various degrees of violence and generosity, in some places bountifully watering the life growing on the land, and in others denying its gifts and relentlessly brushing off the dust with blazing gusts of winds that rob away life of its moisture. They developed a different relationship with the earth, life, and the sky, one that was linked with the uniqueness of their life experience. Some soon found themselves returning to dense forests, feeding mostly on fruits like their distant ancestors, while others rediscovered the coastline and the largesse of the seas, the cradle of life that could sustain them with fish and mollusks. They thus spread across the face of the earth, on the different continents that continued to drift away from one another, only impeded in their course by the highest peaks and abyss of the oceans.

The scattering of the first men and the great variations in the relationship that the different peoples formed with the earth, life, and the sky implied that these forces of nature would from now on shape these populations differently. Generation after generation, the play of affinity and strife, love and war, indeed continues to be unfolded. Some groups suffer the hardest trials of the earth and the sky, struggling daily to survive their wrath, which kills the inept, the unfit, while it rewards those who triumphed over the rage of nature by offering them the spoils of the deceased. Those living in

the northern latitudes, where the winter is cold and inhospitable to life, must save food collected during the summer or starve, while those who are seemingly blessed by the heavens, enjoying year-round crops and an abundance of the fruits of the land, will not be pressured to broaden the horizon of their mind, thinking in terms of days or weeks rather than planning for a whole year.

The shoots thus grow increasingly distant as they themselves turn into branches following a considerable number of revolutions of the celestial wheels. Each one of them is shaped like a piece of clay, with the earth and the sky playing the role of potters. Where the sun strikes man's skin with all its might, such as the treeless plains close to the equator, a darker skin suffers less damage from the assaults from the fiery orb, and as a result, men with a darker complexion progressively replaced the more light-skinned members of their kind. In parts of the dry land onto which the clouds refuse to pour out their liquid wealth, food is scarce and poor in nutrients, affecting the size of those living on this part of the earth, condemning them to be short and lean. Those continuously being robbed of their warmth by the rains, the winds, and the glacial soil see the fire of their own life extinguished more easily if their skin is hairless, and thus such conditions favor those who have preserved some of their ancestral coat, whereas those agonizing from the heavenly flames and scorching gusts sweeping the earth find relief in abandoning it completely, laying their skin bare and inviting their own heat to rise unto the sky, born by the air to the heights, given back to the great luminary from which it came. The pressure put on the walking ones was nonetheless not limited to the earth and the sky, as life itself can also become a potter shaping them. When competition between branches of life, or between tribes and individuals, is particularly fierce, as they fight for love and war, mates and resources, those able to outwit the others may be those who prevail. This may have been one of the factors leading to the fact that we possess a brain twice as large as the one of our first walking ancestors, one that, in contrast to apes, continues to grow after birth.

As a result of the great scattering and shaping of the various branches of walking men, which soon conquered Africa, Europe, and Asia, a diverse humanity emerged. Mankind was further enriched when these branches, sometimes isolated for long periods, began to be interlaced with one another, producing new shoots

that would harmoniously combine the unique features of their parents, rekindling the play of love and war, reproduction and selection, by increasing the variety of their kind, allowing the unveiling of new possibilities for life. Mankind then exhibits a considerable variety of appearances, with skins as dark as ebony or as light as snow, azure eyes mirroring the shades of the clearest sky, or crimson hair like glowing flames, according to the part of the earth they call home. This diversity strengthens mankind, by rendering men more likely to survive a catastrophic event such as the one that brought down the reign of the “fearful-lizards.” The wider is the range of the libraries of information embedded into each cell of each individual, the more likely they are as a species to open up new possibilities for their own evolution, unlocking new doors in the space of all the possibles combinations of bases at the root of all living things.

Man, despite all his might and his domination over the tree of life and the surface of the earth, the prowess of adaptation and evolution that he exhibited across the entire history of his bloodline, back to the very first spark of life, nonetheless remains incredibly feeble in front of the unfathomable power of the skies and the steady force of the earth. His existence always hangs on a fine thread, as he is at every instant threatened to be taken back to death, into the entrails of the earth. What is man in front of a mountain range piercing through the clouds and rooted in the fiery depths of the planet? A mere leaf he is as he stands upon a peak while a host of shadowy clouds invade the heavens, accompanied with torrential showers, lightning bolts, and whirlwinds taking up all that they find on the ground. One special gift has nonetheless been bestowed to him, one that should invite him to humble himself and honor what is greater than him: the fact that now begins to realize his own place within nature. As noticed by the French philosopher Pascal:

Man is only a reed, the weakest in nature, but he is a thinking reed. There is no need for the whole universe to take up arms to crush him: a vapor, a drop of water is enough to kill him. but even if the universe were to crush him, man would still be nobler than his slayer, because he knows that he is dying and the advantage the universe has over him. The universe knows none of

Figure 11.1: *Humans*.

this.²

At the dawn of our kind, our forefathers may have been more aware of their place within nature than their descendants, who now live sheltered in cities made by their own hands, with the earth and the sky veiled on the horizon. The then-nascent consciousness of the first man is feeble and transient, but it already allows him to honor the forces of nature while perceiving the fact that he somehow can also stand out from their flow. His world stands upon the firm earth, and it is borne by living bodies caught between earth and sky, made of flesh and blood, but it also transcends all three realms, containing things that neither belong to the earth, to life, or to the sky, interlacing them all to produce something standing out from them. These are the products of his imagination, of his power of creation, things that may be expressed with the earth such as buildings, inventions, or artworks, but cannot be reduced

²From: Blaise Pascal. *Pensees*. Penguin UK, 2003. n.p. ; Original French: “L’homme n’est qu’un roseau, le plus faible de la nature, mais c’est un roseau pensant. Il ne faut pas que l’univers entier s’arme pour l’écraser ; une vapeur, une goutte d’eau suffit pour le tuer. Mais quand l’univers l’écraserait, l’homme serait encore plus noble que ce qui le tue puisqu’il sait qu’il meurt et l’avantage que l’univers a sur lui, l’univers n’en sait rien,” from: ———. *Pensées de Pascal*. Dezobry et E. Magdeleine, 1852. Page 20-21.

to their earthly nature. In this sense, man towers over the creation, even though he might be swallowed at all times by the whims of the earth, life, or the skies. Continuing to edify his world, passing on his knowledge to his descendants, he then accumulates discoveries, uses the earth and life to serve his own interests, making increasingly complex assemblies of earthly matter to protect his life and prolong it. This work of edification of the world nonetheless does not imply the end of the evolution of his flesh. On the contrary, this worldly construction would once again reinvigorate the play of love and war, reproduction and selection, as world and earth, mind and body, are inextricably interlaced one with the other, and therefore the edification of the former has ineluctable repercussion on the latter.

The most skillful builders and dwellers of the world, those endowed with a talent to form, grasp, and manipulate signs that allow a flow between world and earth, life, and sky, that is, gestures, sounds, or facial expressions expressed on the earth and imparted with a meaning revealed in man's mind, may indeed be more successful players of the game of life. Juggling with signs with an unwavering ease, the master of the world brings the members of his tribe together, leading them to work for their survival and prevailing over their foes, sharing knowledge and rudimentary ideas through simple sounds and gestures and therefore strengthening the whole that they form while they face others, many of which are inept players of this game. Life therefore favors the skillful builders and dwellers of the world. Their skills are nonetheless only partly learned. Just like the most accomplished sculptor would be impotent to create his artworks without the steady and agile hands offered to him by life itself, the world-builder first needs to be endowed with an adequate instrument with which he could play the *meaning-ful* tunes that would bring men together and flow between earth and world. The apes were given an expressive, hairless face with a fine network of muscles underneath their skin that allowed the emergence of meaningful facial expressions, signs, part of their world, which were shared with those beholding their countenance. As a result of the play of love and war, reproduction and selection, which favored those able to express themselves with a wider range of signs, their early human descendants certainly used a considerably larger palette of signs, potentially expressing themselves with their entire body, including a great variety of sounds emitted from

their mouth. This selection, by which man's world shaped the flesh of his kind, resulted in profound changes in his vocal tract, which would ultimately lead to the last great step of the evolution of the body of our ancestors: the emergence of spoken, articulated language.

The grunts and shouts of the early man slowly turned into speech, as his throat and mouth were shaped by the play of love and war, favoring the individuals able to finely tune the sounds coming out of their body, producing harmonious and clear sonorities distinct from one another. No matter how intelligent an ape is, one would lose his time trying to teach him to speak, as even though it can express itself using hands and shouts, his vocal apparatus simply is not adapted to the production of articulated speech. Descendants of the "knowing man," *Homo Sapiens Sapiens*, on the other hand, were at some point selected by life itself for this ability. Once the inept players and the unrefined instruments were winnowed out of mankind through the play of love and war, man exhibited a remarkable aptitude to set countless parts of his upper body in motion, harmoniously and precisely marrying his breath with the vibrations of his vocal cords, directing this flow of audible wave through his mouth, fine-tuning it using his tongue, his palate, or his teeth, remodeling this aural river to transform its monotony into a melodious cascade, like when the white radiance of the sun is decomposed into all the shades of the rainbow by raindrops suspended in the sky. Expertly playing his instrument, offered to him since birth by life itself, he uses it to reinforce his dominion upon the face of the earth, upon the other branches of the tree of life, and also upon the other shoots of his own branch, his distant cousins who may not have been endowed with such a gift, but with whom he nonetheless bred and mixed his blood.

Equipped with a versatile instrument, man then explored the range of sounds that he could produce with it, which is considerable. Mimicry certainly occupied a central place in this work, as the sounds of the earth, life, and the sky were turned into signs, part of his world, referred to with his voice, imitating the voice of nature. The terrifying detonation of thunder became a roar in man's throat, while the soothing lapping of a brook became a soft, gentle rolling of the tongue on the palate. The wondrous nature of man's speech is nonetheless not found in the range of sounds he can produce, nor is it determined by how vividly can he imitate

the voices of nature, as a parrot would indeed surpass him in such a task. The true miracle of his language resides in the capacity to articulate signs in a continuous flow, exhibiting structures themselves endowed with meaning, allowing the use of words to depict an infinite number of situations, painting precise landscapes, real or imaginary, using these words as ink on a canvas. Contrary to the birds, which use their songs to communicate with a very limited number of signs, many of which are innate rather than learned, or the bees using chemical signatures to coordinate their work, man's speech is virtually boundless. He can create new words at will, and use them as building-blocks to edify his world toward greater heights, away from the earth.

Man's speech, which is the first manner in which he uses language, is fundamentally linked with the sky.³ Firstly, it is built linearly, like a flow running in parallel with the passing of time, the work of the heavens. Speech is also ethereal, carried by the air enveloping the face of the earth and life, and soon fading away into oblivion, whether it is heard or not. The air, part of the celestial forces, serves as the messenger of mankind, bringing men together when the sun is veiled under the horizon, leaving the star powerless to guide the steps of the paragon of life, the creature standing upward, pointing to the inscrutable depths above. Diligently ministering to mankind, the ether supports not only the fire burning inside man's flesh but also acts as a pillar supporting a considerable portion of his world. Deprived of this clear fluid enfolding his kind, man would not only choke, he would be deaf and mute, and his instrument would be rendered utterly useless, unable to hear the voice of nature and to reply to it. Language is nonetheless more than speech.

Even alone, with his mouth shut, man can still continue to use the language he learned from his parents, speaking to himself while not letting his words escape the confines of his world, producing thoughts rather than speech, which are neither carried by the air nor heard by his fellow men. These thoughts are made possible because of his previous experiences speaking with others, but

³Writing, which would later emerge at the beginning of our history, is on the other hand very earthly, consisting of marks made of ink on pieces of parchment or imprints of a stylet on tablets of clay or wax, even though the recent introduction of electronic screens has somewhat eroded this earthly nature of the written word.

enclosed within his world rather than propagated through the air, these “inner words” allow him to articulate the fruits of his imagination, to transform his impressions and emotions into worldly structures built with signs, which can then, when he feels the need to and finds an appropriate opportunity to do so, be shared with other men by uttering these thoughts aloud, throwing them to the heavens to be dispersed across the face of the earth, and across the world of the members of his branch of the tree of life.

The birth of mankind represents a turning point for the evolution of life as a whole. As a creature thrown into a world largely built by his own hands and his own mind, through which he sees and interacts with the earth, life, and the skies, he is the first being that sees its own place within the flow of the creation, the work of the skies whose wheels unceasingly turn, carrying the earth and the life growing on its surface. Most men will not, but man is now capable of resisting and opposing the instincts carved by life itself into the core of each one of his cells. He can refuse to make the play of love and war the purpose of his being, the center of his existence. Realizing that he is himself a pawn of the game played by the forces of nature, including the whole of life itself, he may take the decision to break the rules, rather than reject the play altogether. He can seek, find, and nurture love, without binding it to his instinct pushing him to reproduce, to pass on the inheritance accumulated by his ancestors since the first spark of life. He can wage wars, strive, and annihilate without it being linked to the task of trimming the tree of life of its weakest, most unfit elements, by elevating himself above others, to secure the wealth of the earth and the love of mates. Such behavior, standing out of the flow of nature, will nonetheless remain a cryptic anomaly, as if all men rebelled against the play of love and war, and refused to submit themselves to their instincts, their kind would soon vanish, becoming a dead branch of the tree of life.

Expressing himself through arts or spirituality, activities of the world that have a purpose outside of the refinement and extension of life, which were the destiny of all living things that came before him, man can therefore enjoy a new freedom, one that is inextricably tied to his mastery of language, which allows him to not only stand out from the flow of nature but also to stand up against the earth, the skies, and even life itself. Transcending the instincts that push him to assume his role of pawn in the play of love and

war that drives and guides the evolution of life, man can oppose life and embrace death, undermine the middle realm to work for the strengthening of the earth or the skies. Such treasonous behavior is a possibility, but not necessarily something that would benefit him, or even simply provide him with pleasure. The freedom to refuse, to deny, may be seen as a prerequisite to a true, willing participation in the work of edification and refinement of life. Man may betray life, contrary to any other lifeforms, but he alone may also plainly commit himself, heart and mind, to the realm to which he belongs. Endowed with consciousness and language, man may finally prostrate himself to the earth as earth, as something that is more than the surface upon which he roams or the matter from which his flesh and bones are made, but something that is grasped by his mind, as a part of his world, incarnated in a word: "earth." He alone sees himself in the mirror of his world, beholding the entirety of the tree of life, extended not only over the surface of the earth and in the sky but also throughout time, observing the traces left by its growth and imagining where it is headed, what is its destiny. This is what allows him to embrace life as life, as the majestic tree rooted in the earth and whose arms reach out toward the heavens, the sun that sustains it in particular, seeing himself as a mere cell, whose insignificance and expendable nature does not nullify its contribution to the whole. Finally, man alone extends his palms toward the sky as sky, with fear and trembling, love and a longing for communion with the whole, with all that is encompassed by them, and what may lie beyond them.

The play of love and war will nonetheless continue to drive most of mankind, as prehistory ends and history begins. This play will adapt itself to the nature of its pawns, which will increasingly become creatures of the world rather than earthly ones. Their desires for love and war, reproduction and selection, will now be expressed with words as much as with deeds. The magical power of words will attract and repulse, express affinities and strife. Sweet compliments will help men and women to conquer the heart of a loved one, while acerbic reproaches and insults will stir up conflict and lead to battles where blood will be spilled on the earth, contributing to the trimming of their branch of the tree of life, and thereby furthering the evolution of their kind. Touching remarks will create bonds between men, while bitter whispers will lead to the severance of others. The world is then hastily built by men,

progressively veiling the work of the forces of nature, blinding man to his condition while he encloses himself in walls made of earthly rocks and worldly signs, as he begins to build cities and libraries gathering what his kind has created using language, in a great movement of inflation of his world. Many will become enslaved by this world and will be used as the tools of the world as well as tools of other men, who will wield the strength of their bodies and the sharpness of their minds in the same way the early men used blocks of flints and dead branches to fulfill their own desires, often destroying them in this process. Others will nonetheless use their hands and their tongue to nurture life, to benefit their kind, to elevate themselves toward the skies, and to humble themselves by embracing the body of the earth from which they came. The journey of mankind at this point is only at its beginning, and its story, worthy of being told in detail, is one that shall be recounted and explored in another volume.

Re-flection: The Voice in Us

The path taken by our bloodline has been long and sinuous, from a single molecule to a human body, and we now stand at the summit of the tree of life, able to contemplate its branches covering earth and sea. Our kind has been a blaze uncontrollably growing during our history, with a dramatic flaring up in our time, and while this fire has unlocked many secrets of nature, it also threatens the tree of life like never before.

Emboldened by our successes as we now shape the face of the earth, soar through the depths of the sky, and place all forms of life under our yoke, we consume all that falls into our hands, turning it to ashes. The traces of the hands of man are now omnipresent in the world around us, hiding the wonders of nature, and peering through our windows, we may attempt to find signs of the earth and the sky still visible.

Our greatest wealth, our most precious skill, nonetheless may allow us to change the course of our kind, as our language offers us a way to gain consciousness of inconspicuous dangers and to find remedies to any woes. Audibly uttering a word, we may feel the air filling our lungs vibrating as it flows out of our body, and see how our entire flesh and bones accompany this invisible dance of each one of our cells and molecules.

The flow of air, to which our vocal cords have imparted movement, is shaped by our mouth, our tongue, our teeth, as our mind plays with this instrument of life to allow meaningful notes to resonate through the sky. As these notes reach the ears of those sufficiently close to us, they penetrate the world of this audience, and they cease to be a mere dance of molecules suspended in the air to become words, bricks of meaning.

Entering into a slow dialogue with another person, marking long pauses between each interaction, we may pay close attention to the marvelous nature of language, and the place it occupies in our lives. Each sentence is a complex articulation of concepts, things of the world created by our fathers, and it represents a flow running from our world to the earth and the sky, in the form of a vibration, effortlessly poured into the ears of another man, seeping into his world and becoming part of it.

So important is the place of speech in our existence that we may see ourselves as trumpets of life, as we are not merely endowed with an instrument playing the tunes of our world for the pleasure of others, but rather *are* such instruments, our nature now being inextricably linked with this ability. Almost every action of our daily life involves the playing of such tunes or the hearing of those of others, and without language, a man is often unable to participate normally in the edification of the world.

The shaping of our body into such an instrument occurred last, as the crown of our evolution, and this is what allows us to re-*flex* on the story of the tree of life and imagine its future. Our world is supported by our bodies, this congregation of bits of earthly matter bewitched by life, and if these bodies were to crumble, nothing would remain of this world, all meaning would suddenly fade away.

The mightiness of our tongue nonetheless also allows us to become conscious of the threats to our being, and even though we have put the lions in chains, brought the mammoths to extinction, and cut the tusks of elephants, the smallest living things, viruses, may one day cut away our branch of the tree of life entirely. Humility should thus be in order as we behold the majesty of the tree on which we leisurely sit.

Our evolution has nonetheless not been brought to an end with the birth of articulated language, and as we take a glance at the variety of bodies found among our species, we may see how it continues. The play of love and war is now largely unfolded within the world as much as upon the earth, but its effects are as present as they ever were, guiding our kind to improve its fitness to a continuously changing planet.

We can look at the various shades of skin, the shapes of our skulls, the variety of hues of our hair, and consider the fact that this diversity is the best means life gave us to survive impending dooms. The wider our branch is, the fewer chances it has of being cut off and brought back to the earth, and seeing our own flesh, we may see a unique experiment of life, possibly the source of a new evolution. We may now let our thundering voice resound in the depths of the earth and heights of the sky, proclaiming the fruits of our work of reflection, pouring out our essence to offer it to all men.

Conclusion

The present book has offered the reader the opportunity of a re-flection, a walk back in time to examine the birth and growth of the tree of life, treading in the footsteps of the long line of ancestors out of which we all emerged, up from the first seed of life, and witnessing the wondrous nature of the heritage of each generation preceding us, which can be seen and felt in each part of our body. The tree of life lives within us. It flows within our veins and forms the skin that separates us from death. It is the fire that warms our flesh and allows us to resist the frigidity of the winter, the darkness of the nights. We are not merely the descendants of innumerable beings that have preceded us to the grave and been reclaimed by the earth but also a living embodiment of the entire course taken by our bloodline, caught between earth and sky and shaped by them since the infancy of our planet.

Beholding the vastness of the skies, the brilliance of the sun, the abyssal depths of the oceans, or experiencing the firmness and stability of the earth, we should now see in them the shapers of our own being, the potters that formed our flesh from rocks, water, air, and light. Patiently working through the eons, these forces of nature, greater than any individual living thing that ever lived, left their imprint in our body. The sun offered us our eyes, while the waters of the ocean were poured inside our frame to support the fire of life burning within us. The winds blowing over the surface hardened our skin, while the hardness of the earth and its downward pull gave us our bones. Life nonetheless also shaped itself, as it shaped the heavens, offering us the celestial storehouse from which we draw the air that we breathe and that allows us to consume the remains of other living things to preserve our own fire of life.

The tree of life is nonetheless wide, and our lineage only represents a single branch of this remarkable phenomenon. Looking at the birds gliding through the air, the insects burrowing into the soil, or the countless beasts that fill our lands, we may consider the uniqueness of the course of their kind, research how much do we share with them and when did their ancestors part from ours. Even when interacting with death, what is not alive, we may see the traces of our distant forefathers and cousins, whose work of molecular edification, turning death into bricks of life, has passed through large parts of the history of life. What may appear to be most artificial of all substances, the plastics found in almost every object present in our habitations, are indeed formed from the liquefied remains of luxuriant forests that once covered parts of the earth that are now arid deserts or submerged by the sea. Life and death, life and earth, are continuously flowing in and out of one another, as life transforms the earth as it fights death, while individual living beings ineluctably are reclaimed by it. Seeing the emerald canopy that envelops the earth, in the form of forests, grasslands, or verdant cities, what we observe are the last leaves of the tree of life, driving a wedge between earth and sky, joining them both while keeping them at bay. An entire lifetime would nonetheless be insufficient to contemplate the fullness and the extent of this wonderful tree.

As fascinating and marvelous as it is, life nonetheless appears to be only a particular manifestation of the play of attraction and repulsion that rules the earth encompassed by the sky, that is, the matter filling the space in which it is plunged as it passes through time. The line between life and death is somewhat blurry, traced by the mind of man rather than an objective reality, the truth of nature, but the peculiarity of life makes it stand out from the rest of the creation. Life is a fire that consumes the earth and the fruits of the skies, air and light, transforming what it burns as its flames dance over the face of the earth or in the depths of the seas, fanned by water rather than quenched by it. The play of attraction and repulsion between atoms and molecules grows in size and complexity as bits of earth are enthralled by the fire of life, and this leads to the emergence of new, higher orders of the play of matter: mere attraction and repulsion soon becomes affinity and strife, and then love and war, as cells bind their fate together to form complex organisms, and these organisms compete with one

another to cheat death and ensure their own posterity, the transmission of their essence and inheritance. Life is a chain-reaction taking hold of matter, the earth, one that slowly covered the face of our planet as it grew more refined with the passing of the eons. This chain-reaction has continued, uninterrupted, since it first was set into motion by the forces of nature, and we ourselves are mere parts of this gigantic phenomenon, nonetheless finding ourselves in a unique position, as creatures capable of contemplating the tree of life as a whole.

Our knowledge of the details of the budding of the tree of life, and many steps of its growth, remains patchy and incomplete, but the big picture of its nature, the mechanisms of the evolution of life and the outline of the course it took, is already sufficiently clear to allow us to appreciate its refinement and splendor. More subtle and demanding than the stories of yore explaining the origin of our being, the story of life depicted in the previous pages may also appear more beautiful, as it shows that the play of attraction and repulsion, love and war, is a remarkably simple foundation, upon which the most elegant, complex, and imposing edifice can be built, exhibiting the perfection of the creation, the elegance of our universe, whose origin remains completely inscrutable. The horizon of our consciousness is still being enlarged year after year, as men stubbornly attempt to find meaning in the earth, life, and the skies, but we should already be grateful to live in a time that knows so much about the nature and origin of life. The work of our forefathers allows us to behold the tree of life, perceiving its nature rather than merely seeing its current appearance, watching the fullness of its trunk, branches, and buds rather than only the emerald canopy representing the leaves of the current season, the living beings covering the face of the earth right now. Contemplating the tree, we now can not only see the life on earth present around us but also the course taken by life as a whole as the heavenly wheels revolved since the germination of its first seed. Examining each part of our own body, we now begin to perceive their origin and purpose, which is often linked with a precise time and place, and represents a reaction of life to a pressure exerted by the earth, another part of life, or the sky upon it. The greatest secrets of our body have been uncovered, but man is nonetheless more than mere flesh and bone.

The birth of mankind marked a formidable expansion and

refinement of the world that began to be built following the emergence of nerve networks among animals. This “world” is the set of all the representations of the earth, life, the skies, and the world itself, which are stored and used by all animals, the way they see the creation. Life first gave the animals a rudimentary world built through natural selection, the play of affinity and strife, before they developed the ability to learn and build their world as a response to the flow of information poured into their network of nerves by their senses. With the ability to learn and build their world, the representations shaping their own behavior, life not only passed on an inheritance etched with molecules forming the seeds of new beings, but it also began to pass on worldly information through teaching and learning. The end of the evolution of our body, as described in the present work, therefore does not mark the end of our story but rather the beginning of history, the time when the edification of our world began to grow so fast as to dwarf the continuing evolution of our flesh, rendering it almost imperceptible. The vision of the nature of life and our body offered in the previous pages therefore only represents the first part of the journey, the story of our being, as it focused on our earthly nature, the origin and evolution of our flesh. Man’s worldly nature is nonetheless certainly as important as his earthly one, and the examination of the nature and evolution of this world should be as worthy of study as the one of the earthly evolution of life, what we technically call “biology.” The story of man’s world should therefore also be told, and the author of these words hopes to soon be able to offer the reader his own depiction of it,⁴ but everyone may nonetheless contemplate the history of this world by himself, seeking to realize the role it plays in his life.

The first part of the journey should nonetheless already represent a well from which insights may be drawn to quench the thirst of those yearning for meaning and fulfillment. It invites us to reconsider our relationship with life as a whole, including our kinsmen, our people, and our species. Conscious of the nature of the play of love and war that guides our kind, we are now offered a unique opportunity to steer the course of life in a new direction, one chosen according to our will, within certain boundaries set by

⁴This work has now been published, see: Antón Bousquet. *The Walls of Things Around Us – Philosophical (Hi)story of Technology and Mindfulness of the Human Environment*. Koadig, 2023

nature itself. From mere actors of the play, men may now become playwrights and directors, shaping life with their hands and minds according to their vision of their common destiny. Early in their history, men began to take into their own hands the transformation of certain branches of the tree of life, by influencing the play of affinity and strife, love and war, themselves deciding which creature would be allowed to mate and produce offspring. Men thus tamed the ferocious wild wolves and turned them into inoffensive poodles or faithful shepherds, transforming the beasts into companions. They bred the fattest and least hairy of the wild boars to turn them into pigs, raised and butchered for their succulent meat. The hand of man thus began to shape the tree of life, through conscious actions rather than as a mere byproduct of their own struggle to survive and reproduce. Our forefathers thereby strengthened the dominion of our kind over the other branches of life, changing the destiny of many of them so that they would benefit us, allow us to grow in numbers and resist the offensives of nature, of other living things, and even of death.

The work that man has done to shape countless species of plants, fungi, or animals, to bend them to fit his every whim, he nonetheless could also perform it upon himself. From immemorial times, men have indeed discussed this possibility willfully shaping the human species, but every experiment toward this goal seems to have been short-lived, bearing few fruits. The major problem does not reside in the ability of man of doing so, but rather in the ethical questions that inevitably come with the possibility for man to (re)shape his own nature. We alone have been offered the power to shape the bodies of future generations according to our vision of what they should become. Concerning men, the Greek philosopher Heraclitus told us that:

When they are born they wish to live and attain their fate (or rather, to cease from life) and they leave behind children to become their fates.⁵

We can now not only pass on our legacy to the next generation,

⁵From: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 169. Original Greek: “Γενόμενοι ζῶειν ἐθέλουσι μὲν τέχνην (μᾶλλον δὲ ἀναπαύεσθαι) καὶ παῖδας καταλείπουσι μὲν γενέσθαι.” from: Graham, *The Texts of Early Greek Philosophy. Part 1*. Page 168.

letting the play of attraction and repulsion, affinity and strife of our seeds nurture new discoveries, opening new paths for our species to explore, but also can decide many characteristics of their bodies, replacing the fruit of the play of nature by one devised by our minds. We are nonetheless now faced with an important choice: should we wield this prodigious power bestowed unto us by nature? An answer to this question is inextricably linked with the question of the destiny of mankind, one that has no definitive answer. As we observe the nature of the play of attraction and repulsion, affinity and strife, love and war that rules and guides the evolution of the whole of life, it would seem that the goal of life, the destination towards which it tends as it grows and passes through time, is merely to propagate itself while continuously adapting to the menaces threatening the swelling of its mass covering the face of the earth as it is carried in the flow of time. Many men will be amply satisfied with a life of submission to the script of this play, striving daily to survive and find (an) appropriate mate(s) with whom they will give birth to a new generation, enthusiastically embracing their role in the play, living like every one of their predecessors, each link binding it to the very first spark of life. Others, especially among those who with clarity see the role assigned to them in the great play in particular, will nonetheless not be satisfied by it, and they will strive to deviate the course of their life, and sometimes want to influence the course of mankind as a whole so that all would reach another destination.

Man is the first creature able to consciously steer the trajectory of his kind, transcending the imperatives dictated to him by his instinct, etched with bases in the library of information in the core of each one of his cells, to choose where he wants to go, or what destination he wants his descendants to reach. Freeing himself from his instincts, man may nonetheless decide to simply accelerate and assist the growth of the tree of life, keeping the same trajectory and only assuming the role of a diligent gardener. One way by which this marriage of will and nature could occur is through the continuation of the elevation of life. Life indeed began in the sea, the watery womb of the earth, and it then elevated itself above the surface of the waters by crawling onto the dry land. Animals furthered this elevation by conquering the lower skies by frenetically beating their wings, relentlessly struggling to liberate themselves from the downward pull of the earth and soar above the

summit of the highest mountains. Man went even further during the past decades, achieving for the first time a complete liberation from the smothering embrace of the earth, plunging living things into the depths of space, the higher heavens.

The ascent of life, from the depths of the earth to the heights of the skies, may be embraced by man as a part of his destiny, a heavenly call. The severance from life's natural habitat, the surface between earth and sky, and the long-term survival and thriving in other parts of the universe, would nonetheless demand not only feats of engineering but also profound transformations of our bodies. Through selective breeding and manipulations of the libraries of information of earthly forms of life, man may be able to give birth to living things that may flourish on distant planets, planting seeds of new trees of life in different corners of the universe. He may also apply the same methods to his own kind, transforming his descendants to allow them to durably live far away from the only known home of life, thereby ensuring that when our benevolent star, the sun that nurtured the growth of life on earth, ineluctably dies in a cataclysmic explosion that would reduce our planet to dust, life could perdure, taking refuge near another celestial luminary. Such a destiny may nonetheless be seen as a mere conscious extension of the natural course of life, which tends to propagate itself as far away as it can, adapting itself to new surroundings. Other courses are nonetheless also possible.

Man may accompany the natural course of the evolution of his kind and accelerate its pace, but he may also decide to oppose or hinder it. Unwillingly caught in the unceasing and all-encompassing struggle between the forces of nature, between the different branches of the tree of life, and between individual beings, he was drafted and sent to play a role soon after his birth. Having grown up, he may now see the nature of the play and consider it vain or even repugnant, and this may lead him to take a new stand, to choose to play a different role in the great struggle unfolded through the vastness of the universe and the flow of time. One may decide to forsake mankind and strive to undermine its dominion over the earth, the other branches of life, and the sky. This may be done through the destruction or dismantlement of man's means of exploitation of life, such as industrial agriculture or livestock raising, or the earth, such as quarries, mines, and oil-drilling facilities. Modern "ecology" may thus be seen as a man

taking a stand in favor of the whole of life or the earth, struggling against his instincts, which push him to continuously prolong and tighten his grip over the rest of the creation. This path may even lead him to the most extreme positions, such as viewing the human race as a disease infecting the earth and that should be wiped out to protect "mother earth." One may even imagine a willingness to extend this malevolence to the fire of life as a whole, with men striving to quench it for all eternity, making themselves the ultimate allies of death, enemies of life, ending their macabre quest by enthusiastically ending their own being. This ability to forego one's own interest for the sake of the other is certainly one of the most singular features of our kind, one that may inspire both terror and admiration.

Man has been offered the gift of the choice of the role he plays in nature, even though his instincts invite him to remain an obedient actor of the play of love and war, a mere pawn whose life is focused on survival and reproduction. Such a choice is therefore demanding, as it first implies a consciousness of the existence and nature of the play and an unclouded vision of the horizon of nature. It will also raise profound ethical questions, forcing men to ponder the consequences of their actions of manipulation of the course of nature. We in recent years have uncovered the technical means of rewriting the libraries of information of the seeds of most living beings, allowing us to directly intervene in the course of life's evolution, but the men who will have considered the moral implications of such work will be reluctant to wield these new tools, knowing that the consequences could be devastating, for man and life as a whole. Sooner or later, however, men without such scruples will walk the face of the earth and will boldly wield these tools without consideration for any moral implications. They will give birth to monsters living a life of agony and despair in the name of science and progress, lowering our kind to new spiritual low points, but life may nonetheless ultimately benefit from such terrifying works. There may indeed lie the key for life's survival and man's ascent toward the highest heavens.

An essential aspect of mankind, perhaps the one that makes him the "paragon of animals," is nonetheless his capacity to transcend his earthly and heavenly nature. He not only inhabits the face of the earth, under the sky, but also dwells in a world, largely built by his own hands. This world is borne by the earth, itself

carried by the skies, but it also stands out from them. The infinite number of representations, fruit of the imagination and reflection of mankind, may be supported by our brains, but only our mind can decipher these astonishingly complex patterns of nerve interactions and turn them into images, concepts, and thoughts. Man is more than flesh and blood, more than a fruit of the marriage of earth and sky, and thus his destiny may perhaps be sought in his world rather than in the tree of life growing between these two realms. The tree is set on a course determined at the beginning of life, by the play of affinity and strife, reproduction with variation and selection, but our world, the fruit of our capacity to reason, may offer us a more singular destination, another end to our being.

Man may thus decide to be the gardener of the tree of life or his destroyer. This represents a stand regarding the material nature of life, its “earthiness.” He may nonetheless also take an opposite stand and disregard this nature completely to plunge himself entirely into the world, what appears to transcend earth and sky, to find his destiny in spirituality, rejecting his own earthly and heavenly nature to seek refuge in the “meta-physical,” what appears to transcend the material and the temporal. Between these two extremes, a middle-way may perhaps allow man to reconcile his yearning for transcendence, for liberation from his earthly and heavenly nature, and the reality and inexorability of his embodiment, the fact that his existence depends on his flesh and blood, the fire of life burning within him, which may find itself quenched at every instant. No man is inextricably compelled to remain a pawn of the play of love and war, or forced to deny his own nature to free himself from the great play and find his own destiny. Man’s destination may lie within himself, and be reached through an appropriation of his own nature, allying earth and world, body and mind.

A true appropriation is more than mere ownership or subjugation. It implies an understanding, a constant consciousness of the nature of what is meant to be appropriated. The invitation to a work of reflection on each major step in the evolution of our body that has concluded each chapter of the present book can be seen as part of such a journey of appropriation of our nature. To be mindful of the origin, the role, and the functioning of each part of our body, striving to keep these insights in front of our eyes and

in the reach of our other senses at all times, is a way for us to experience our earthly and heavenly nature, that is, the fact that we are made of matter, plunged into space, flowing through time, thereby allowing us to feel in our bones our direct connection with the entire tree of life, and with the earth and the skies themselves, extinguishing the vain yearning for a purely meta-physical existence, as an ethereal mind beyond the heavens, severed from the embodied experience of nature that defines our being. Re-flection, understood as man turning his attention to himself, to his source and destination through a meditation practice involving both mind and body, the intellect and the senses, encourages us to follow the steps of a man described by Empedocles, the philosopher of life:

There was a man among them of extraordinary knowledge, who had earned the greatest wealth of wit, of every sort of especially wise works the master. For whenever he reached out with all his wits, easily did he behold each of all existing things for ten or even twenty generations of men.⁶

A work of re-flection on life may extend the horizon of our consciousness far beyond twenty generations. Seeing and feeling the different branching of the tree of life as we focus our attention on the nature of each part of our body, we may indeed witness the work of our entire bloodline in our skin, our bones, our senses, our organs, and our nerves. Examining each one of them, we may see the result of the work of the earth and the sky upon life, performed eons ago, whose traces are found all over our flesh, and which will be passed on to our children.

The sentences written by life itself in the library of information at the heart of each one of our cells tell a large part of the story of life as a whole, and some of their words have been written down billions of years ago, making these pieces of life more resistant and long-lasting than the hardest rocks surrounding us. They will probably remain when all our cities made of concrete and our

⁶From: Graham, *The Texts of Early Greek Philosophy. Part 1.* Page 411. Original Greek: “Ὦν δὲ τις ἐν κείνοισιν ἀνὴρ περιώσια εἰδώς, ὅς δὴ μήκιστον πραπίδων ἐκτήσατο πλούτον, παντοίων τε μάλιστα σοφῶν ἐπιήρανος ἔργων. Οὔποτε γὰρ πάσῃσιν ορέξαίτο πραπίδεςσι, ρεῖά γε τῶν ὄντων πάντων λεύσσεσκεν ἕκαστα καὶ τε δέκ’ ἀνθρώπων καὶ τ’ εἰκοσιν αἰῶνεςσι,” from: Graham, *The Texts of Early Greek Philosophy. Part 1.* Page 410.

books written on paper have returned to the ground, showing the futility of our attempts to shape the earth according to our whims. A consciousness of this antiquity and nature of our own body may do more than satisfy our curiosity or our thirst for knowledge and understanding. Looking at our origin and the course of our kind may perhaps be the surest means to find guidance toward our own destiny. Appropriating these insights into the nature of life, through a continuous practice involving man's own senses and the entirety of his body rather than being a mere intellectual contemplation, he may indeed free himself from the yoke of the play of love and war, liberate himself from the chains of his instincts, which often are a source of discontentment, frustration, and despair.

The play of attraction and repulsion, affinity and strife, love and war, is what drives the growth of the tree of life and it is the source of our being, our existence. If we are strong and intelligent, it is because our ancestors diligently played their role in it, mercilessly fighting against one another to prevail and relentlessly resisting the countless assaults of the forces of nature that tried to extinguish the fire of life. As man is nonetheless the first creature to have been offered the choice to pass judgment upon the nature of this play, his destiny may perhaps be to represent the end of life, its culmination, not needing a further evolution. As he can now see the stage upon which the play is unfolded, from afar, standing in the heights of his world built by his mind, he may decide to become a mere spectator of the play, a connoisseur who stands in awe in front of the magnificence of this artwork of nature, trying not to affect or be affected by it. Stepping out of the stage of the play of love and war, man finds himself enfolded by indifference and peace, which contrary to love and war are not two contrasting elements but rather a single one.

The appropriation of the body and the mind through a reflection practice can offer man a chance to experience life through a new point of view, one of someone who is not a mere pawn in the great play, but rather someone who may at times choose to contemplate it from afar, knowing the peace that comes from detachment and non-duality, that is, the dissolving of the self in the whole, but also willingly and consciously decide to return to the stage and play the role assigned to him by life itself, with his lines written down in the library of information of each one of

his cells and expressed by bodily instincts, plunging himself again in this sea of love and war, joy and pain, to remind himself of the sublimity of the difference between love and war on the one hand and indifference and peace on the other, himself becoming the director of a play in which he freely leaps between these two stages where the play of nature is unfolded, which also represent two stages of man's evolution.

A vision of man's destiny may also perhaps be found in the account of the end of the great philosopher of life, Empedocles, who, when old age came upon him, decided not to wait for the fire of life to turn his decrepit body into dust but rather to embrace death by sublimating his flesh by throwing himself at night inside a fiery volcano, "so that his body would disappear."⁷ Having let go of the fear associated with the survival instinct, part of the play of love and war, and conscious of the ineluctable return of life to death, the philosopher showed a mastery of his own self. Refusing to be a pawn of the play, trembling while awaiting the return to death and delaying it as much as he could, he chose the night, the time when the life-giving sun is veiled and most living creatures lie still, waiting for the dawn, the time when the darkness associated with death cover the earth, to embrace the fire coming from the depths of the earth, the same fire that fanned the first sparks of life, thereby cleaving his flesh into ash and smoke, part of it offered back to the earth, while the other ascends to the heavens, the winds carrying his substance over the land, before the rains brought his remnants back to the ocean, where life began.

⁷See: Graham, *The Texts of Early Greek Philosophy. Part 1.* Page 337.

*Disce non diligere, ut discas diligere;
avertere, ut convertaris;
funde, ut implearis.*

Learn not to love, that thou mayest learn to love;
Turn away, that thou mayest be turned to;
Pour out, that thou mayest be filled.

— Saint Augustine⁸

⁸English translation from: Augustine. *Expositions on the Book of Psalms: Psalms 1-36*. John Henry Parker, 1847. Page 274. Latin original from: Aurelius Augustinus. *Sancti Aurelii Augustini, ... Opera omnia post Lovanien-sium theologorum recensioem, castigata...* Migne, 1841. Page 254.

Timeline

The following timeline should give the reader an overview of the chronology of the growth of the tree of life. It should nonetheless be noted that this chronology is not the subject of a consensus. It is neither precise nor absolute, and the flow of new discoveries made year after year by researchers would ineluctably cause it to soon be rendered obsolete. The dates are based on various sources, some of which are listed below.

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M.y.a.	Event	Ch.
13 800	Big bang	
4 540	The hadean eon begins	
4 540	Earth forms	
4 450	Moon forms after a collision	
4 280	Liquid water appears on earth	1.1
?	Organic compounds appear	1.2
4 000	The archean eon begins	
3800	First self-replicating molecules	1.3
3500	First cells	1.4
3000	The proterozoic eon begins	
2400	The great oxidation event	
?	First endosymbiosis	1.8
2200	Aerobic cellular respiration	1.9
1850	Eukaryotic cells	1.10
?	Flagellar mobility	1.11
1200	Sexual reproduction	1.12
1200	Multicellularity	1.14
580	First animals	1.14
550	Muscles	1.15
550	Nerve networks	1.16
550	Bilateria	1.17
?	Social animals	1.18
540	The phanerozoic eon begins	
530	Vision	1.20
520	Blood circulatory system	1.19
510	Vertebrates	1.21
365	First limbs	1.22
	Conquest of the land by vertebrates	
370	First land vertebrates	2.1
395	Four-legged animals	2.2
330	Live births	2.3
320	Claws and hard skin	2.4
250	Warm-blooded animals	2.5
250	Furry animals	2.6
225	Mammals	2.7
66	Cretaceous-paleogene extinction event	
60	Primates	2.8
20	Apes	2.9

4	Early men	2.10
0.2	Men	2.11

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